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SEA-WATER SYSTEM DESIGN AND OPERATIONS OF THE MARINE CULTURE LABORATORY, GRANITE CANYON[1]

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A marine culture laboratory, incorporating a dual sea-water intake and delivery system, was developed on the central California coast south of Monterey. The sea-water system is continuous flow design, includes a 94,625 liter (25,000 gal) storage capacity, and provides for filtered, heated, chilled, ultraviolet sterilized and raw (unaltered) sea-water. The submersible intake collector was especially designed to withstand strong surf conditions at the open-coastal laboratory location. Operations of the laboratory are described and major equipment items, and systems are discussed in detail.

INTRODUCTION

In 1970 the California Department of Fish and Game established a Marine Culture Laboratory at Granite Canyon, located about 19 kilometers (12 miles) south of Monterey on State Highway 1 (Figure 1). This laboratory was developed to: (i) explore the feasibility for mass cultivation of selected marine species, (ii) improve existing mariculture techniques and (iii) develop selective shellfish strains that possess desirable characteristics for mariculture. Funds for the Laboratory development and operations are provided in part under the Bartlett Commercial Fisheries Research and Development Act (P.L. 88-309).

The initial planning phase for the Marine Culture Laboratory began in 1965. Early effort was directed towards selection of a suitable location. High priority considerations included good quality sea-water and a central geographic location. The coast south of Monterey met both these criteria.

The laboratory site at Granite Canyon is located in an undeveloped open coastal region bordered by precipitous granitic formations that rise 24.4 m (80 ft) or higher from the ocean. The steep seacliffs and rugged open coastal location is subjected to severe wave action, particularly during winter storm periods. This necessitated the design of a sturdy sea-water collector and pumping system.

The main laboratory (Figure 2), at 30.5 m (100 ft) above sea level, was originally constructed as a U.S. Navy missile tracking station. Few alterations were necessary in the conversion of the building into an adequate laboratory. The most challenging task was to install a satisfactory sea-water system, including adequate drainage from wet laboratory areas.

Prior to construction of the sea-water system project biologists visited several marine laboratories and oceanariums along the California-Oregon coast. Valuable knowledge was obtained from these

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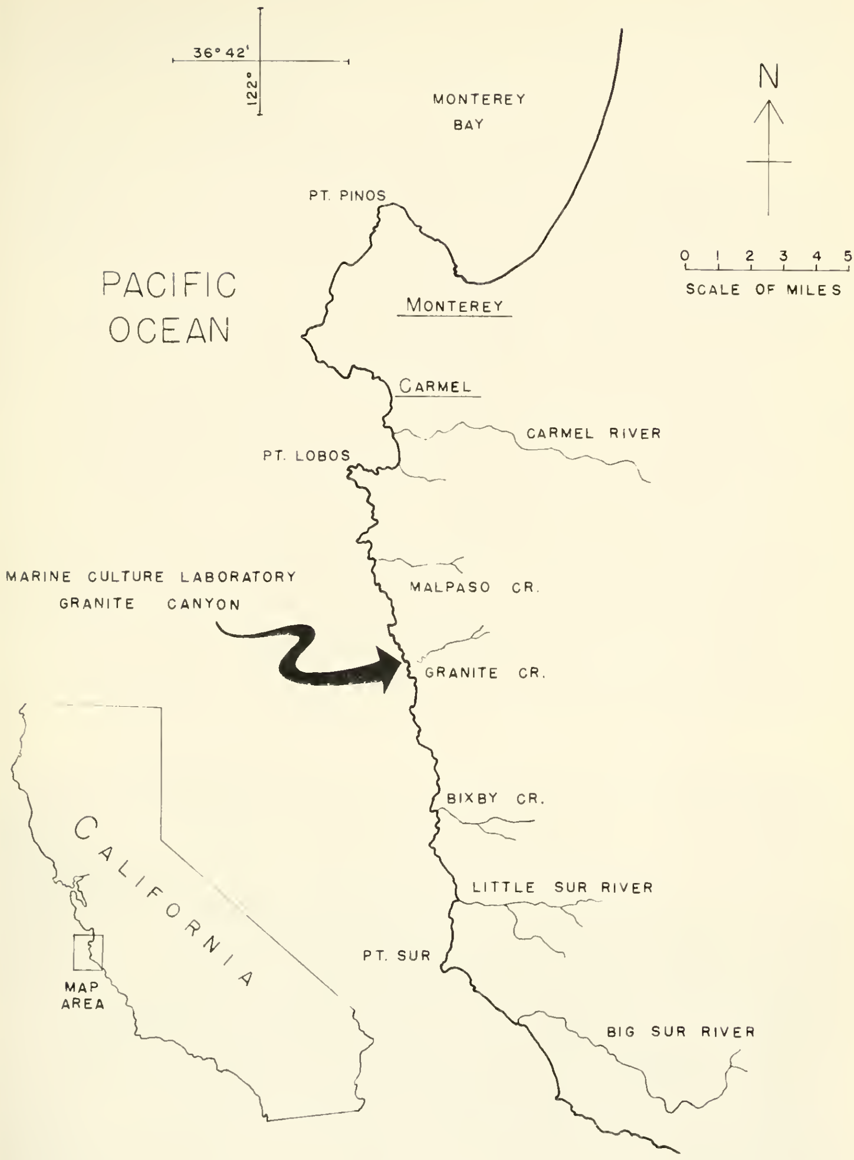

FIGURE 1. The central California coast showing the location of the Marine Culture Laboratory south of Monterey.

visits, enabling us to evaluate the merits and shortcomings of various sea-water system designs and components. Information obtained served as a guide in designing the sea-water system, and selecting equipment.

A wealth of literature exists on sea-water systems. Particularly noteworthy is a collection of papers edited by Clark and Clark (1964). However most sea-water systems incorporate some unique feature or

harbor a quirk or "bug" that was not envisaged in the design phase. Therefore it behooves those involved in sea-water system design and operations to publish their findings, so that others may avoid serious pitfalls and accordingly benefit from proven systems.

SEA-WATER INTAKE AND DELIVERY SYSTEM

The sea-water pumping and delivery system to the laboratory consists of a collector unit anchored on the seafloor, housing dual submersible pumps, dual delivery pipes to a main storage reservoir of 75,700 liters (20,000 gal), and dual delivery lines from the main storage reservoir to the laboratory (Figure 3).

The collector weighs approximately 9,000 kg (10 tons). It is constructed of two 50.8 cm (20 inch) diameter asbestos pipes 2.54 cm (1 inch) thick and 3.96 m (13 ft) long. Centered inside each 50.8 cm pipe is a 25.4 cm (10 inch) diameter asbestos pipe of the same length and thickness as the outer pipe. The space between the two pipes is filled with 9.5 mm ($\frac{3}{8}$-inch) diameter gravel. One submersible pump is sleeved inside each 25.4 cm asbestos pipe. Both the 25.4 cm and 50.8 cm asbestos pipes are slotted to allow water passage. The gravel pack serves to filter large particles and debris that could clog or damage the pump impellers, yet is coarse enough to allow passage of small planktonic organisms. The asbestos pipes, gravel pack and pumps are all contained within a framework of 10.2 cm (4 inch) tubular steel pipes with 12.7 mm ($\frac{1}{2}$-inch) thick steel endplates (Figure 4). This entire assembly is anchored on the seafloor at a depth of 4.8 m (15 ft), reinforced with steel and 4.2 m^3 (12 yd^3) of concrete.

FIGURE 2. Marine Culture Laboratory, Granite Canyon. The main laboratory building is to the right, and the holding laboratory and attached greenhouse to the left. Photograph by Glen Bickford.

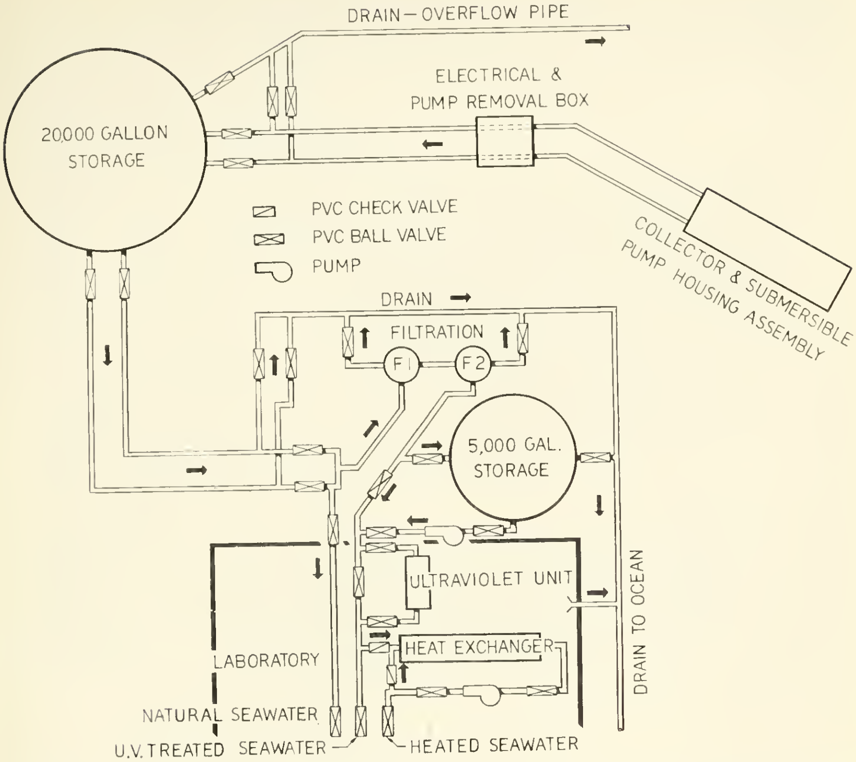

FIGURE 3. **Schematic of the sea-water intake, storage and delivery system. Drawing by Robert E. Smith.**

The 10-hp submersible pumps (F. E. Myers, "S.C.S." series), each have four cast iron impellers and are rated at 568 liters (150 gal) per min. The pump impellers and casing are epoxy coated. The pump impeller shaft is stainless steel. Water is pushed from the pumps through 10.2 cm polyvinyl chloride (PVC) pipes to the 75,700 liter redwood storage reservoir situated 36.6 m (120 ft) above sea level. This storage reservoir is lined with 0.25 mm (10 mil) thick, clear, polyethylene film. Dual 10.2 cm PVC pipes deliver sea-water from the main storage reservoir to the laboratory by gravity flow. The main storage reservoir is located 6.1 m (20 ft) above the laboratory level.

The main function of the dual pumping and sea-water delivery system is to minimize fouling by marine organisms. This is accomplished by monthly alternating use of the delivery lines. Settled organisms desiccate and die in the pipe not in use. Appropriate valves are provided throughout the dual piping system such that sea-water can flush out pipes and be shunted to drain. This is an absolute necessity when pipes and pumps are alternated so as to avoid contamination of laboratory water by dead organisms accumulated in the pipe that had been shut-down. The dual pump and sea-water delivery system also serves to provide a back-up during maintenance or repair operations, or when emergency situations arise.

SEA-WATER FILTRATION AND STERILIZATION

At the main laboratory building the sea-water delivery pipes bifurcate; one 7.6 cm (3 inch) pipe enters the laboratory directly as natural or "raw" sea-water and provides plankton to filter feeding organisms. The remaining 7.6 cm supply pipe passes into a two stage high transport sand filtration system (Baker Filtration Co., Model HRE-236). Filtration to approximately 15 μ (0.59 mil) is achieved with these units. These high transport sand filters require periodic backwashing to flush accumulated material that clogs the filter media. In this system it is a manual process and requires approximately 5 min for each filter. The frequency of backwashing varies depending upon the amount of particulate matter being pumped through the delivery pipes and has varied from daily to weekly, or slightly longer.

Filtered water normally passes directly into the laboratory, however, valving is provided to shunt part of the filtered water into a 189,250 liter (5,000 gal) storage reservoir. This stored, filtered sea-water is used to supply the laboratory while the Baker filters are being backwashed. This assures a continuous supply of filtered sea-water in the laboratory.

Additional filtration is provided in the laboratory to 10, 5 or 1 μ (0.39, 0.20, and 0.04 mil respectively) by employing Filterite cartridge filters (Filterite Corporation). GAF calibrated polypropylene strainer bags (G.A.F. Corporation) are also used for particular applications and provide an effective, inexpensive method of filtering sea-water.

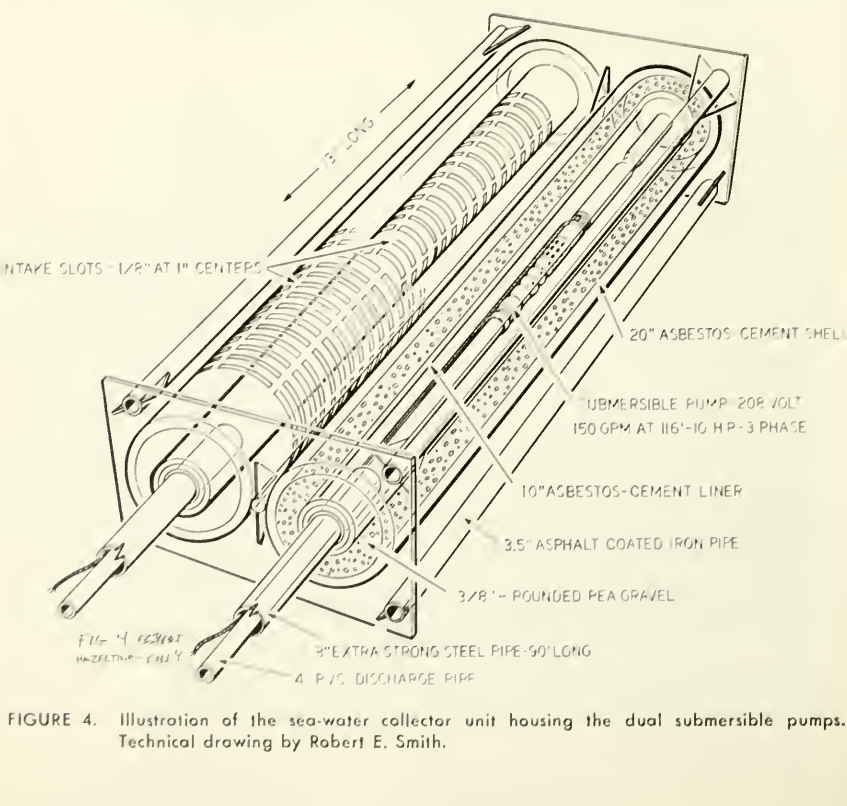

FIGURE 4. Illustration of the sea-water collector unit housing the dual submersible pumps. Technical drawing by Robert E. Smith.

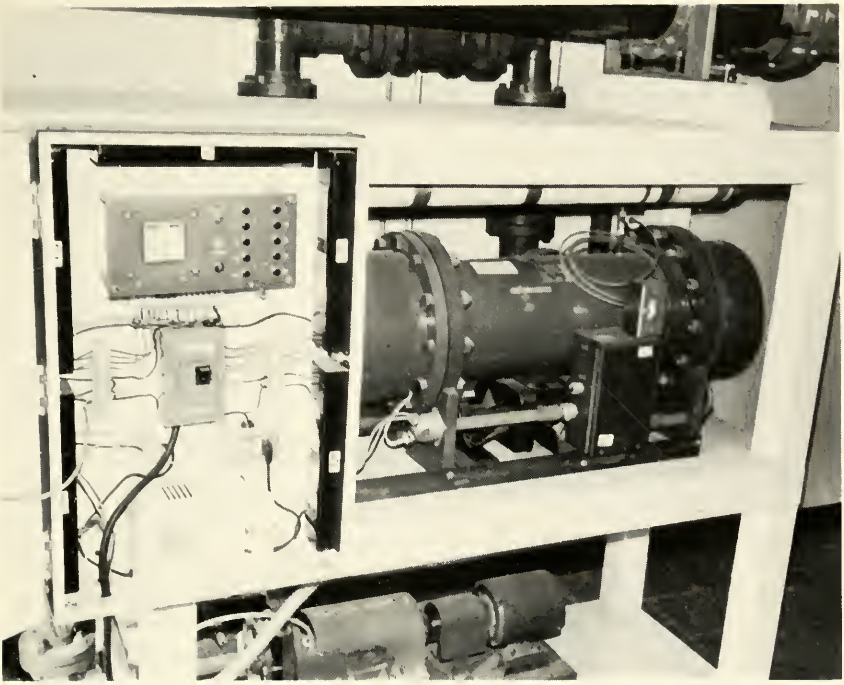

FIGURE 5. The main 10-tube UV unit. Panel on the right indicates efficiency of UV lamps. The Vanton pump used for circulating warmed sea-water is at the bottom of the photo. Photograph by Arthur W. Haseltine.

Bacterial control is accomplished with a 10 lamp ultraviolet (UV) unit (Steri-Tronics International, Model SWL 80/120), rated at 99% bacterial removal for 303 to 454 liters/min (80 to 120 gpm) water flows. The UV unit is positioned in the filtered water system just inside the laboratory (Figure 5). A secondary, two-tube UV unit (Aquafine Corporation, Model MP-2—PVC) is connected to a 1μ filtered sea-water line and used in forage culture operations where bacterial control is extremely critical.

HEATING AND CHILLING SEA-WATER

A check valve arrangement allows passage of filtered sea-water, on demand, into the heated sea-water system. This system is comprised of a PYREX brand modular heat exchanger (Model 600 GNB), a 500,000 BTU freshwater boiler, and a $\frac{3}{4}$-hp plastic lined pump (Vanton, Chem-Gard, Model CG-PY200). This pump operates continuously to circulate the warmed water and insure uniform temperatures throughout the system. Sea-water temperature is controlled automatically by a pneumatic valve positioned in the freshwater pipe, between the boiler and heat exchanger. This pneumatic valve is connected to, and actuated through a control panel. A temperature sensor, positioned in the heated sea-water pipe, is also connected to this panel. The control panel records heated and ambient sea-water temperatures, and contains a salinometer (Beckman Model RA5).

Heated sea-water is used in a variety of applications that include; conditioning of animals for spawning, inducing them to spawn by thermal shock, establishing temperature regimes for optimal growth and survival, and determination of thermal tolerance limits.

Sea-water is chilled by means of portable refrigeration units (Frigid Units Inc., Model DI-33-T) that are designed to mount above selected reservoirs. These chiller units incorporate a titanium circulator that is in contact with sea-water; however this metal is inert, and does not release toxic ions.

LABORATORY COMPLEX

The main laboratory building comprises about 335 m^2 (3,600 ft^2) of floor space. The sea-water system itself passes through three wet laboratories contained within the main structure. Inclusive is a 93 m^2 (1,000 ft^2) conditioning and spawning laboratory, a 32.5 m^2 (350 ft^2) laboratory for culturing larval stages, and a forage culture laboratory of 46.5 m^2 (500 ft^2). Sea-water circulates through each laboratory by means of an overhead, trapeze supported assembly of pipes (Figure 6). These pipes are arranged in a loop-system to minimize "deadends" where toxic materials could accumulate. Appropriate valving is provided so line flow can be stopped to individual laboratories without disrupting other services. Provisions are included in the raw water line for ease of disassembly so that fouling organisms can be mechanically removed. This removal is accomplished by sleeving a PVC pipe, one size less in diameter, through the fouled pipe. Additionally a heat

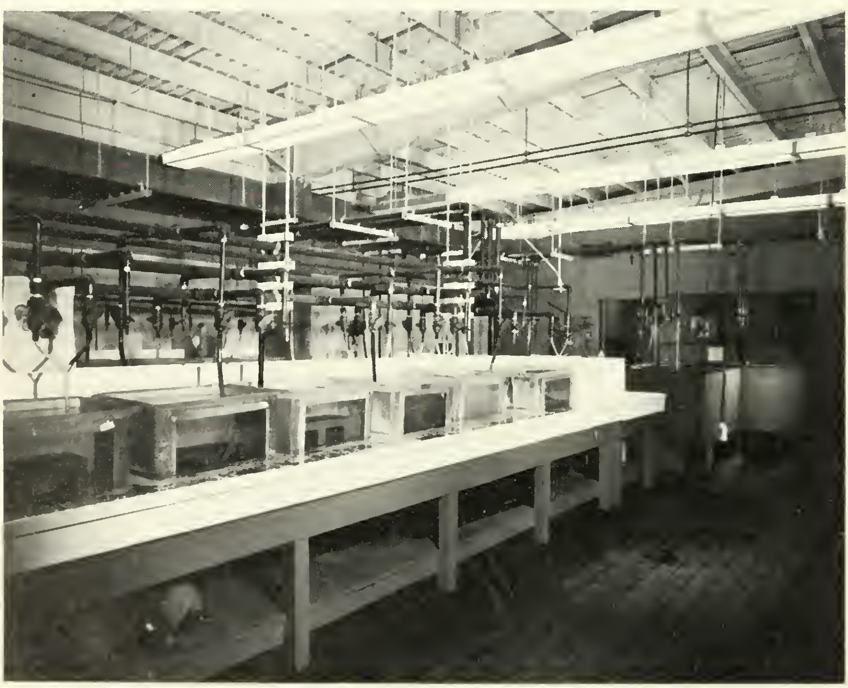

FIGURE 6. The conditioning and spawning laboratory showing the trapeze supported piping assembly, and layout of water tables and reservoirs. Photograph by Vince Arrant.

treatment clean-out is provided, employing freshwater, to eradicate fouling organisms.

Nearly one-half the conditioning and spawning laboratory wet area is occupied by three movable water tables. The water tables are constructed of oak wood frames and have epoxy coated, fiberglassed plywood water bath inserts. These inserts have inside dimensions of 5.13 m (16.8 ft) by 0.90 m (2.9 ft) by 0.13 m (0.4 ft) deep. Fiberglass aquaria of 75 liter (approximately 20 gal) capacity are normally positioned on these water tables to hold and condition shellfish.

Two sinks, similar to the water tables, and positioned near them, serve to spawn shellfish such as oysters and abalones. These sinks have inside dimensions of 0.90 m by 0.91 m (nearly 3 ft) by 0.13 m deep.

Additional reservoirs in the conditioning and spawning laboratory have both circular and rectangular configurations, are flat bottomed, and are constructed of fiberglass (manufactured by Frigid Units, Inc.). The rectangular reservoirs have inside dimensions of 2.07 m (6.8 ft) by 0.55 m (1.8 ft) by 0.52 m (1.7 ft) deep. Removable, plastic screened, partitions are provided for these reservoirs. The circular reservoirs have an inside diameter of 1.22 m (4 ft), are 0.76 m (2.5 ft) high, and have a centrally located standpipe. Circular tanks are particularly useful for maintaining adult ovigerous crustaceans in a continuous flowing water system. To retain newly-hatched swimming larvae in these circular tanks a plastic framed, nylon screened "box" is fitted over the standpipe (figure 7).

Nylon screen (NYTEX brand, manufactured by Tobler, Ernst and Traber, Inc.) is used in the laboratory for several applications. This screen is available in a wide assortment of mesh sizes. NYTEX screen is particularly useful for fabricating sieves. In this application we bond the NYTEX to 15.2 cm (6 inch) diameter PVC pipes, of varying lengths, using PVC cement. These sieves have proven invaluable for screening larvae.

The larvae culture laboratory contains two water tables constructed of the same materials as those in the conditioning and spawning laboratory. However, the water bath inserts are shorter and deeper, having inside dimensions of 2.17 m (7.1 ft) by 0.90 m by 0.25 m (0.8 ft) deep. These water tables function to maintain uniform bath temperatures for animals.

Also located in the larvae culture laboratory are four circular, fiberglass reservoirs. Two have cone shaped bottoms with drain valves at the apex. These reservoirs are used principally for culturing oyster larvae, and are patterned after those frequently observed in oyster hatcheries. The remaining two circular reservoirs have concave bottoms and measure 1.05 m (3.4 ft) in diameter by 1.3 m (4.3 ft) tall and are also used principally in oyster culture operations.

The forage culture laboratory contains space for culturing phytoplankton and zooplankton, and for cleaning, sterilizing, and storing glassware. A large portion of this laboratory has a low, corrugated fiberglass ceiling to aid in maintaining desired temperatures. Also, this laboratory contains a sink similar to those in the conditioning and spawning laboratory, and shelving for holding 19 liter (5 gal) Pyrex carboys used for algae cultures. To enhance algal growth, fluorescent lamps (40 w bulbs) are affixed above the carboy shelves. Two major

FIGURE 7. Circular, flat bottomed fiberglass reservoir depicting the screened box over the standpipe for retention of shellfish larvae. Photograph by Arthur W. Haseltine.

equipment items occupy the forage culture laboratory; a 0.55 m^3 (19.6 ft^3) autoclave, custom designed for this project (Dundon Iron Works, San Francisco), and a 183 cm by 244 cm (6 ft by 8 ft) walk-in environmental room (Controlled Environments, Inc., Model C608), used for maintaining small algae cultures. Miscellaneous equipment in the forage culture laboratory includes: a shaker bath, centrifuge, colorimeter—spectrophotometer, UV transfer hood, drying oven, and a fresh water demineralizer-distillation unit.

Drainage from wet laboratory areas could not be accomplished by the usual method of channeling the floor due to the existing building design. Therefore raised duck-boards were constructed, drain pipes were located beneath them, and the floor was sealed with layers of hot-tarred felt paper. All drain pipes vent out one side of the building. Contained water then passes into a 15.2 cm collector pipe that runs the length of the building and directs drain water back to the ocean.

Adjacent to the main laboratory is a 65 m^2 (700 ft^2) building that serves to hold shellfish and provides space for rearing juveniles on a pilot-scale basis. Reservoir capacities in this structure range from 600 to 4,000 liters (about 158 to 1,000 gal). All reservoirs are constructed of fiberglass; those of larger capacity are circular and have a flat bottom.

Attached to the holding facility is a 28 m^2 (300 ft^2) greenhouse designed for mass algae cultivation. The greenhouse roof and one-half the side walls are constructed of transluscent fiberglass panels to utilize

solar effects and enhance algal "blooms". Here, single species of unicellular algae are cultured in 700 liter (about 185 gal) circular, flat bottomed reservoirs.

LABORATORY OPERATIONS

Biological studies commenced in December, 1970. A multi-species approach was decided upon that includes both crustaceans and mollusks.

Priority species under investigation include the red abalone, *Haliotis rufescens,* the Pacific oyster, *Crassostrea gigas,* and the spot prawn, *Pandalus platyceros.* Culture studies have also been accomplished on the market crab, *Cancer magister,* and to a limited extent, on the spiny lobster, *Panulirus interruptus.*

Red Abalone

The red abalone study is to examine known culture techniques, and develop new techniques in order to enhance the mariculture potential of this species.

Pacific Oyster

The Pacific oyster study is to develop a resistant strain. This oyster frequently experiences high summer mortalities in commercial growing areas of central and northern California. Causative factors of these mortalities are largely unknown. The study approach was to select old oyster stock known to have survived several high mortality periods, spawn these and distribute the progeny onto growing beds. The assumption being that the adult stock had developed an inherent resistance to the factor(s) responsible for summer mortalities and would transmit this to their offspring.

Successful Pacific oyster spawnings and seed (spat) sets were obtained in the spring and fall of 1972. These progeny were distributed onto growing beds and a quarterly monitoring program was established. It is anticipated that the progeny of the 1972 spawnings will be returned to the laboratory in late 1973 for spawning of a second generation of oysters, hopefully possessing good survival characteristics.

Spot Prawn

Research upon the mass cultivation of the spot prawn has been in progress since March, 1971. The spot prawn is the object of a limited, but valuable local fishery. They grow to a relatively large size. Wild stocks harvested from the fishery have a heads-on count of 8.8 to 22.0/kg (4 to 10/lb). In the laboratory the spot prawn lends itself exceedingly well to mass cultivation procedures. However the growth rate needs to be improved in order to achieve an economically feasible venture. One-year-old laboratory cultured spot prawns, nurtured on a diet of mixed natural foods, average 21.7 mm (0.85 inch) carapace lengths, and have an average weight of 7.1 g (0.016 lb).

Market Crab

The market crab was successfully reared through the five zoeal stages, the megalopa, and to the first crab instar. However, extensive mortalities occurred at each developmental stage and only a small number obtained the first crab instar. Cause of the high mortalities is unknown.

Forage Culture

Forage culture represents an integral and specialized element of the overall laboratory operations. Close coordination must be maintained with shellfish hatching periods to insure adequate quantities and types of forage for larval shellfish. At the Marine Culture Laboratory unicellular algae species such as *Isochrysis galbana, Monochrysis lutheri* and *Phaeodactylum tricornutum* are routinely cultured for oyster larvae rearing, experimental feeding to crustacean larvae, and supplemental feeding to adult filter-feeding mollusks.

The brine shrimp, *Artemia salina*, is the principal zooplanktor cultured. It serves as forage for certain crustacean larvae (e.g. spot prawn, market crab and spiny lobster). Additional zooplanktors cultured and examined for suitability as forage include copepods, and larvae of the echiurid worm, *Urechis caupo*.

CONCLUSIONS

The Marine Culture Laboratory at Granite Canyon represents a new discipline within the California Department of Fish and Game's overall structure. The inception of this laboratory is timely since man is in the midst of a mariculture (sea farming) development phase on a near-worldwide scale.

Many countries are increasingly looking to mariculture as a means of better management and utilization of marine resources. It is evident that, for various reasons, California's shellfish resources are not sustaining. It is anticipated that the California Department of Fish and Game's Marine Culture Laboratory, with its central geographic location, good water quality, well designed sea-water system, and versatile program for developing culture techniques, will play an active role in developing the science of mariculture and improving California's shellfish resources.

ACKNOWLEDGMENTS

We are indebted to Paul W. Wild, a former project member, who provided valuable assistance in the design and installation of the laboratory sea-water system. Harold Orcutt and Robson A. Collins offered editorial assistance.

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Calif. Fish and Game, 00(1): 15–22. 1974.

NOTES ON COLLECTION OF SHINER PERCH, *CYMATOGASTER AGGREGATA* IN BODEGA HARBOR, CALIFORNIA[1]

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During the summer of 1971, we recorded the distribution and reproductive condition of *Cymatogaster aggregata*, found in Bodega Harbor. Adults were abundant during June and early July, declining in August, with a simultaneous numerical increase of young of the year. Adults were primarily found in the environs of Gaffney Point and young of the year were primarily found at Spud Point and the environs of Doran Beach.

Gravid females were found during the early part of the summer as were males with freely flowing seminal fluid. During the late summer the females were inseminated and seminal fluid was absent in many adult males.

Patterns of distribution in relation to reproductive condition are discussed.

INTRODUCTION

The first extensive collections of the shiner perch, *Cymatogaster aggregata* Gibbons, in Bodega Harbor, California, were made by us during the summer of 1971. This paper presents the results of these collections with emphasis on the distribution and the reproductive condition of the fish. It furthers the study initiated by Shaw (1971) and will allow comparison with other studies of *C. aggregata* along the Californian and Canadian coasts.

MATERIAL AND METHODS

Description of the Study Area

Ten sampling areas (Figure 1) were chosen in Bodega Harbor, a protected harbor 60 miles north of San Francisco Bay at lat 38° 19′ N. The harbor channel is maintained by periodic dredging, and the protecting breakwater is man-made.

Water movement in the harbor is a result of tidal action, and there are no major freshwater inflows. Salinity (Milton Boyd, pers. comm.) is affected only by rainfall and is maintained at sp gr 1.33 during the summer months. The water temperature in the shallower areas ranged from 10 to 25 C, but is a fairly constant 15 C in the deeper parts during the summer, remaining 2 to 2.5 C higher than the open ocean.

The substrate of the harbor is a combination of sand and mud. Large beds of eel grass, *Zostera* sp., are exposed at the lower tides and large masses of algae, *Enteromorpha* sp. and *Ulva* sp. are found intertidally during the summer months. *Ulva* sp. was concentrated primarily at South Gaffney, Gaffney Pt. and the Dorms.

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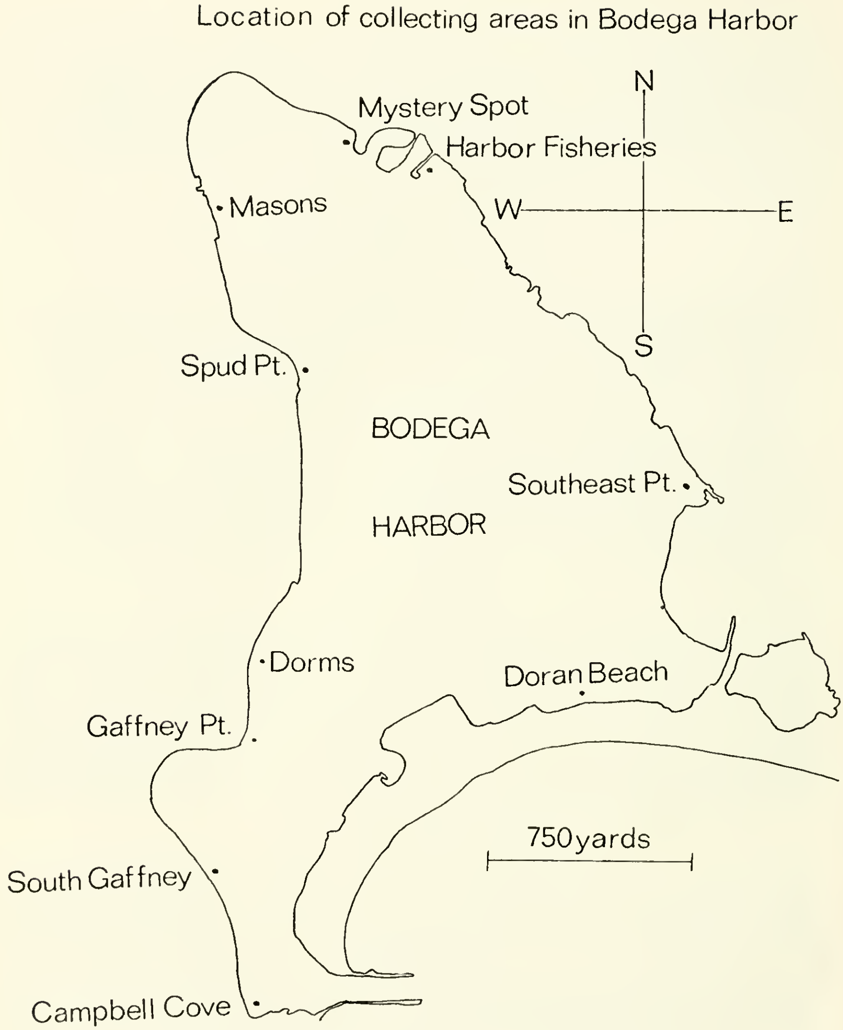

FIGURE 1. Location of collecting areas in Bodega Harbor.

Method of Collection

The main collections were made using either of two beach seines, each 30 m long by 1.6 m high. The mesh of one was 1 cm, while the other had mesh of three sizes (0.8, 0.5, and 0.2) with the mesh size decreasing towards the center of the seine. The seine was pulled manually 33 to 66 m from shore to depths up to 1.6 m. Each sweep covered an area 20 m wide and about 36 m in length. Two collections were made using a 5.0 m otter trawl (mesh sizes of 2.0 cm, 1.5 cm, on the outer bag, and 0.5 cm on the inner bag) in the deeper portions of the harbor down to approximately 4 m in depth. Fish were usually collected at or around the high tides, either at ebb or flow.

After each collection the number of adult males, adult females, and young of the year were counted. Based on the collections of the year before (1971), young of the year were considered to be fish of less than 6.0 cm in length, and adults were considered to be fish of more than 6.5 cm in length. This was a natural separation, since very few fish 6.0 to 6.5 cm were found. A total of 10,503 fish was collected from 104 seine hauls and two otter trawls. Fish taken for laboratory analysis totaled 1,021. These were measured and their reproductive condition was determined. The major portion of the collection was returned to the harbor as quickly as possible with a minimum of handling.

It is likely that a number of fish were re-collected. However, since our principle goal was not to determine numbers of fish, but rather to determine reproduction condition and distribution of young and adults, the occurrence of re-collection does not interfere with the suitability of the data.

Laboratory Analysis

Males

Adult males (fish more than 6.5 cm in length) and young of the year males (fish less than 6.0 cm in length) were examined to see if secondary sexual characteristics were developing or had developed. If a male had developed secondary sexual characteristics, its abdominal wall was squeezed to see if the male was producing freely flowing seminal fluid.

If no freely flowing seminal fluid was obtained, the testes were excised, crushed on a microscope slide, bathed by a drop or two of Ringer's solution and examined under a magnification of 46X. The Ringer's solution enhanced the motility of mature spermatozoa, making them easier to identify (Shaw 1971).

Females

Gravid females in an advanced state were easily identified by their greatly distended abdominal walls. Their ovaries were dissected and the embros counted and measured. Smears of the ovary, made by crushing the ovary and mixing it with Ringer's solution, were examined for the presence of motile spermatozoa.

The ovaries of nongravid females were also examined for the presence of motile spermatozoa. Initially, a capillary pipette was inserted approximately 5 mm into the genital aperture. Some ovarian fluid was withdrawn and treated with Ringer's solution. If spermatozoa were not found in the fluid, the ovary was excised and treated as above.

Young of the year females were checked for the presence of spermatozoa in the same manner.

RESULTS

The first major collection of adults was made at Gaffney Pt. in May. In February to April attempts to locate adults at Spud and Gaffney Pts. were unsuccessful. At that time the water temperature was around 9 C and algae were absent from Spud and Gaffney points. However, about the third week in May, *Enteromorpha* sp. became abundant, water temperature rose to 13 to 14 C and the first major collection was made. Regular collecting began on June 17.

During the entire summer, adults comprised the major portion of the collections at Campbell Cove, South Gaffney, Gaffney Point, and

the Dorms. The young of the year were collected mainly at Spud Point, Masons, Mystery Spot, Harbor Fisheries, Southeast Point, and Doran Beach. At Campbell Cove, and at Mystery Spot, fish were not often found. Adults were found most abundantly near the Gaffney area, and young were found most abundantly around Doran Beach, and Spud Point. The large number of young at Mystery Spot were taken in one haul on August 17. Adults collected at Spud Point, Masons, Mystery Spot, Harbor Fisheries, Southeast Point, and Doran Beach were taken during the early part of the summer, but few adults were found there later (Table 1).

TABLE 1. **Number of Collections and Composition of Collections**

Location	Number of seine sweeps	Percent of sweeps in which fish were caught	Total number of fish	Number of females	Number of males	Number of juveniles
Campbell Cove	10	50	98	30	68	0
South Gaffney	8	100	201	165	36	0
Gaffney Point	18	94	1,168	339	823	6
Dorms	10	80	253	150	93	10
Spud Point	13	100	1,679	177	290	1,212
Masons	6	100	226	11	30	185
Mystery Spot	9	55	1,013	4	5	1,004
Harbor Fisheries	6	100	125	33	37	55
Southeast Point	11	100	3,674	198	197	3,179
Doran Beach	13	100	166	464	148	1,554
Totals	104		10,503	1,571	1,727	7,205

As the summer progressed there was a distinct decline in the number of adults collected. During the latter half of June about 2,500 adults were collected, sexed, and returned to the harbor. During July and August the number collected dropped to approximately 300 a month. Concomitantly, the number of collected young increased from 25 in June to about 7,000 in the July and August collections (Table 2).

The overall sex ratio for the adults was 1.15 males/females. However, some samples showed ratios ranging from 4.2 males/females to 0.31 males/females. We measured 339 females, ranging in size from 6.5 to 12.5 cm SL. The mean length was 10.1 cm. The females tended to be larger than the 281 males we measured, which had a range of 6.5 to 11.0 cm SL and a mean of 9.1 cm.

Reproductive Conditions

Adult Females

We dissected 339 females and classified them as (i) nongravid, not inseminated, (ii) nongravid, inseminated, or (iii) gravid. A total of 29 gravid females was examined and found not inseminated (Table 3). Only four gravid females were taken at Campbell Cove although 30 females were collected there during the summer months. Gravid females were found consistently until the second week of July at South Gaffney, Gaffney Point, and the Dorms. After that, the number of inseminated females increased and the number of gravid females decreased. At Southeast Point and Doran Beach, 38 gravid females were taken on July 17. These fish had highly distended abdomens and appeared to be close to giving birth. Few adult females, regardless of condition, were found there later than July 17.

TABLE 2. **Percentages of Adult Males, Females and Young of the Year Collected During Two Month Period**

Dates	Number	Percentages		
		Females	Males	Juveniles
6/17–6/30	2,615	45.1	50.6	4.3
7/ 2–7/15	1,551	3.8	3.4	92.8
7/16–7/30	3,448	3.25	4.35	92.5
8/ 2–8/11	865	22.0	12.4	65.6
8/13–8/24	2,024	1.6	1.9	96.5
	10,503			

TABLE 3. **Collecting Locations, Dates, and Reproduction Condition Adult Females, Males**

Date	Females				Males	
	Total N*	N G†	N NMS†	N MS†	Total N*	N with motile sperm
Campbell Cove						
7/12	9	2	1	6	7	7
8/ 2	4	2	--	2	2	2
8/11	16	--	1	15	13	11
8/24	4	--	--	4	7	7
South Gaffney, Gaffney Point, Dorms						
5/ 5	14	14	--	--	5	0
5/25	13	12	1	--	5	0
6/ 5	30	29	1	--	5	0
6/17	25	22	3	--	23	0
6/21	15	13	2	--	41	0
6/29	23	17	3	3	28	8
7/ 4	17	11	5	1	16	9
7/12	9	1	--	8	2	2
7/16	12	--	6	6	7	6
7/27	5	1	--	4	3	3
8/ 3	19	--	1	18	8	8
8/ 9	29	4	1	24	16	16
Spud Point						
6/19	12	12	--	--	12	0
6/28	No females				4	3
7/22	2	1	1	--	0	0
8/24	6	--	--	6	8	8
Masons, Mystery Spot, Harbor Fisheries						
6/25	11	3	1	1(?)	10	2
7/11	7	3	--	--	3	2
8/11	6	--	1	1	10	10
8/17	No females				9	7
Southeast Point, Doran Beach						
6/22	19	17	2	--	1	0
6/26	10	9	1	--	14	1
7/17	38	38	--	--	no data	
7/27	9	--	5	4	1	1
8/ 9	3	1	--	2	4	4

* N = Fish examined and/or dissected in the laboratory.
† G = Gravid; NMS = No motile sperm detected in ovary; MS = Motile sperm detected in ovary.

Embryos

Approximately 500 embryos were measured to obtain total length. At South Gaffney, Gaffney Point, and the Dorms, in early June, the measurements ranged from 12 to 16 mm, and in late June from 17 to 28 mm. In late June at Harbor Fisheries, the embryonic length ranged from 20 to 35 mm, and at Southeast Point and Doran Beach from 25 to 39 mm. The number of embryos in each ovary ranged from 6 to 10 with the larger females carrying the greater number of young. Birth occurs when the embryos are 35 to 40 mm in length.

Adult males

We examined 281 males for the presence of motile sperm. A number of males contained motile sperm in June, and by early July virtually all fish had motile sperm (Table 3).

Young of the year females

A total of 213 young of the year females was dissected. Inseminated fish were first found in the collections made during the last week of July. About 25% (N = 15) of these harbored sperm. Subsequently, the percentage hovered around 35 to 40% (N = 81), and, during the last week of August, about 65% (N = 29) of the fish, all 39 to 46 mm in length, had been inseminated.

Young of the year males

Dissections were made of 188 males (37 to 50 mm in length). During the first week of July motile spermatozoa were found in crushed testes. Freely flowing milt was occasionally obtained during the last week of July. Although freely flowing seminal fluid was not regularly obtained during that period, the testes contained motile spermatozoa in about 50% of the males. After that period the percentage declined to 30%.

Motile spermatozoa were always obtained when the bulbous appendages had developed. However, motile spermatozoa were sometimes noted in young males in which only the anterior edge of the anal fin had thickened and no other characteristics had appeared. Freely flowing seminal fluid was noted in two fish which had no secondary sexual characteristics whatsoever.

DISCUSSION

The results of this survey extend and corroborate the findings of Shaw (1971) regarding reproductive condition and distribution of *C. aggregata* in Bodega Harbor. She found adults primarily at Gaffney Point and young of the year primarily at Spud Point. However, she did not make collections in the entire harbor, and thus we are unable to compare our additional findings regarding distribution at other locations. Shaw divided her fish into three size groups: juveniles, young adults, and adults. These groups do not correspond, in size, to our groups.

Adults are not found at Gaffney Point during the winter and early spring, but they are common there during the late spring and summer. Eigenmann (1894) reports an abundance of adults, particularly females, during the winter in San Francisco and San Diego Bays and states that during the summer and fall this species is rarely seen. Bane

and Robinson (1971) report the presence of one year old fish and young of the year during March in Newport Bay, Southern California. The young of the year seem to disappear in April and May, and reappear again in June. One year old adults, however, are found in April and May, not in June, evidently reappear in July and finally disappear in August, leaving only young in the harbor. The adults are found at that time in the ocean. Gordon (as reported by Weibe, 1968) observed, in early June, fish moving into shallow water as distinct schools of yearling males, followed by adult males, then adult females. The first week in July, according to Gordon, is the peak spawning period, and adults move into deeper water during the day, but back into shallow water at night. It is possible that the decrease in our catch of adults during July and August resulted from the adults' being in waters too deep for a seine sweep during the day. However, once mating has occurred, the adults may move out of the harbor into the ocean.

The major point to emerge from the comparison of our collections to the literature is that there is some inconsistency between studies. Contrary to our findings of when *Cymatogaster* appears in Bodega Harbor, Eigenmann (1894) did not find adults (in San Francisco Bay) in the summer, and Bane and Robinson did not find adults (in Newport Bay) in June. Only in Weibe in 1968, reporting Gordon's research, is there similarity to our results. We are left without clear explanation as to the cause of these differences in the adult populations. They may be artifacts of collecting or real differences in distribution and patterns of movement between the fish found in southern California, in San Francisco Bay, and in Bodega Harbor.

Females in different reproductive condition were found at specific locations in the harbor. Gravid females were collected at South Gaffney, Gaffney Point, the Dorms, Spud Point, Southeast Point, and Doran Beach during June. During July and August nongravid inseminated females were found mainly at Campbell Cove, South Gaffney, Gaffney Point, and the Dorms, and few females were collected at Southeast Point and Doran Beach. Young of the year were not found at Campbell Cove, South Gaffney, Gaffney Point, and the Dorms, but were abundant at Southeast Point, Doran Beach, Spud Point, Masons, Mystery Spot, and Harbor Fisheries. We believe that gravid females move away from the Gaffney area to the other areas when they are ready to drop their young. Once the young are dropped, these females return to the Gaffney area where insemination occurs, or they may be inseminated as they return to the Gaffney area. It is possible that the females may bear their young at Gaffney and the young swim quickly away. However, this is unlikely, since collections would then have yielded greater numbers of young in the Gaffney area if they were being born there. The proposition that females bear their young away from Gaffney is reinforced by the fact that females with the largest embryos are found at Southeast Point and Doran Beach. The distances the fish need to travel in the harbor are relatively small, and they may be attracted to warmer temperatures in the other areas. The food supply and algae around the harbor appears to be similar at all locations, except Masons and Mystery Spot, where the collections were poor. The advantage of dropping young at locations such as Southeast

Point and Doran Beach, rather than at Campbell Cove, South Gaffney, Gaffney or the Dorms is in need of investigation.

We should like to add that subsequent collections made during the summer of 1972 repeated the same pattern of distribution found during the summer of 1971.

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THE NOMENCLATURE FOR MYSIDS IN THE SACRAMENTO-SAN JOAQUIN DELTA ESTUARY[1]

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In consulting the existing literature during the course of laboratory and field studies, confusion arose as to the exact taxon of the *Neomysis* utilized as a test organism. This paper presents historic and taxonomic evidence for using the name *Neomysis intermedia* for the mysid from the Sacramento-San Joaquin Delta Estuary which has been called *Neomysis awatschensis.*

INTRODUCTION

Several mysids of the genus *Neomysis* are found in brackish and fresh waters from Monterey Bay north along the western coast of North America (Tattersall 1951). One particular mysid, the opossum shrimp, is important as a food item in the diet of young-of-the-year striped bass (*Morone saxatilis*) in the Sacramento-San Joaquin Delta Estuary System (Heubach et al. 1963). In consulting the existing literature during the course of our studies, which evaluated temperature and salinity tolerances, metabolic rate and gut contents of this particular *Neomysis*, confusion developed as to the exact taxon of our test organism. Specimens were, therefore, sent to A. H. Banner to determine the proper specific name. Since his opinion differs from the currently cited specific name, this paper presents historic and taxonomic evidence for transferring the form in the Sacramento-San Joaquin Delta Estuary System from *Neomysis awatschensis* (Brandt) to *Neomysis intermedia* (Czerniavsky).

DESCRIPTION AND DISCUSSION

The *Neomysis* presently identified as *Neomysis awatschensis* is restricted to the upper reaches of the Sacramento-San Joaquin Estuary (San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta). Specimens collected from Suisun Bay upstream were all the same species. Identification was based on keys from Tattersall (1932) and Ii (1964). All specimens had a rounded rostrum, with the front margins concave. The anterio-lateral edges of the rostrum were long and pointed. The antennal scale was approximately eight times as long as its width; the terminal segment of the scale was sharply pointed and separated by a suture from the remainder of the spine. The fourth pleopod of the male was elongate, covering most of the sixth abdominal segment, with the terminal joint being less than one-fourth the length of the proximal joint. The average adult size, which depends on season, is 10 to 13 mm.

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The specimens presently identified as *N. awatschensis* were initially identified as *N. mercedis* by Holmes (1896). His specimens were collected from Lake Merced, California, a freshwater lake on the San Francisco peninsula. Tattersall (1932), examining mysids of San Francisco Bay, found this same species, mostly in samples taken from regions he classified as the Upper Bay (i.e., San Pablo Bay). On five occasions a few specimens were collected in Middle and Lower Bay. In identifying *N. mercedis,* Tattersall noted its close resemblance to *N. intermedia* and *N. awatschensis* but described features to distinguish them. He separated *N. mercedis* from *N. intermedia* on the basis of the length of the antennal scale (eight times as long as broad in *N. mercedis,* compared with eleven times in *N. intermedia*) and on the proportions of the joints of the fourth pleopod of the male (the terminal joint is less than one-fourth as long as the proximal joint in *N. mercedis,* but is half as long in *N. intermedia*).

Tattersall further stated that *N. mercedis* and *N. awatschensis* can be separated by color, *N. awatschensis* being black, while *N. mercedis* is not black; by size, *N. mercedis* being approximately 5 mm longer; by the number of subsidiary joints on the sixth joint of the thoracic endopods, *N. mercedis* having 8 to 10 joints, while *N. awatschensis* has only 3 to 6; and finally by the shape of the rostrum, round in *N. mercedis* and pointed in *N. awatschensis.*

Between 1896 and 1954, *N. mercedis* was the accepted name for this species in the Sacramento-San Joaquin Estuary. Banner (1954) reexamined three species, *N. mercedis, N. intermedia,* and *N. awatschensis,* utilizing specimens obtained primarily from Washington and Alaska. He found that the characteristics given by Tattersall varied sufficiently to conclude that the three species were synonymous, and gave them the oldest name *N. awatschensis* (Brandt).

This latter designation has been used predominantly in the literature from the late 1960's to the present (see Turner and Heubach 1966; Heubach 1969, and Hair 1971).

The latest reclassification occurred in 1964, when Ii examined the mysid fauna of Japan. He found sufficient evidence, particularly in the shape of the rostrum, to justify separation of the two species, *N. intermedia* and *N. awatschensis.* The rostrum of *N. awatschensis* is pointed with concave lateral margins, while the rostrum of *N. intermedia* is evenly rounded. Ii agreed with Banner that *N. intermedia, N. mercedis, N. isaza* (Marukawa) and some of the previous records of *N. awatschensis* are synonymous and should be called *N. intermedia* (Czerniavsky).

Specimens from the Sacramento-San Joaquin Estuary fitting the description given by Tattersall (1932, 1951) for *N. mercedis*, should, therefore, be designated *N. intermedia.* Banner (pers. comm. February 1973) confirmed our identification and agreed that the appropriate name is *N. intermedia.* The *Neomysis* referred to in the following literature are probably *N. intermedia*:

= *N. mercedis,* Holmes 1896
= *N. mercedis,* Tattersall 1932
= *N. mercedis,* Tattersall 1951
= *N. mercedis,* Heubach et al. 1963
= *N. awatschensis,* Painter 1966
= *N. awatschensis,* Turner and Heubach, 1966

= *N. awatschensis,* Heubach 1969
= *N. awatschensis,* Hair 1971

N. intermedia is not the only species of the genus *Neomysis* found within the San Francisco Bay Region. Tattersall (1932) found four other species, most of them present in collections with *N. intermedia.* These four species were *N. macropsis, N. costata* (now *Acanthomysis macropsis* and *A. costata,* Ii 1936), *N. franciscorum* (now *N. rayii,* Tattersall 1951), and *N. kadiakensis.* The species now referred to as *A. macropsis* and *A. costata* can be separated from the genus *Neomysis* by the shape of the terminal segment of the antennal scale, this segment being rounded in *Acanthomysis* and pointed in *Neomysis. N. rayii* and *N. kadiakensis* have telsons which are long and narrow with numerous lateral spines, separating them from *N. intermedia,* which has a short telson and few (12–15) lateral spines.

Painter (1966), in a year long survey of San Pablo and Suisun Bays, reported only two species of mysids, *A. macropsis* and *N. awatschensis* (now *N. intermedia*). *N. intermedia* was the most abundant mysid and confined primarily to Suisun Bay except for a flood period, when it was obtained within the channel in San Pablo Bay, and during June and July, when it was obtained along the margins of San Pablo Bay. *A. macropsis* was apparently confined to San Pablo Bay.

All of the opossum shrimp we have examined were obtained east of Carquinez Strait and appear homogeneous with regard to species. *N. intermedia,* therefor, is the predominant if not the only mysid in the Sacramento-San Joaquin Delta and Suisun Bay.

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INFLUENCE OF SIZE OF EGGS AND AGE OF FEMALE ON HATCHABILITY AND GROWTH IN RAINBOW TROUT[1]

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The egg production of 2- and 3-year-old rainbow trout females and the growth of their progeny to 75 days of age were studied in two consecutive years to evaluate the effect of egg size and age of female on size and growth of fingerlings. Age 2 females produced smaller eggs than age 3 females making it difficult to separate the two effects.

There were significant differences between years and ages of females in egg volume, egg size, and egg number per female. There was also a significant year by age interaction which was attributed to differences between the two genetic stocks used in the study. Age 3 females gave a higher percent eyed eggs, and larger, more rapidly growing fingerlings. The age of female effects on fingerling size could be accounted for by regression on egg size. Fingerling growth was affected by both age of female and egg size.

INTRODUCTION

Studies of the relationship between fecundity, age, and size of fish in natural populations have shown that in general larger and older females produce greater numbers of larger eggs than smaller and/or younger individuals (Rounsefell 1957; Hanson and Wickwire 1967; Incerpi and Warner 1969). Similar results have been found for a limited number of hatchery-reared stocks of rainbow trout (Buss and McCreary 1960; Gall 1969, 1973). These studies and others (Hempel and Blaxter 1967; Bagenal 1969) have also demonstrated that the more fecund females produce smaller eggs. Gall (1973) working with 2-year-old females questioned this relationship for domestic rainbow trout and suggested that selection for high egg number may have broken any previously existing correlation.

Many workers have conjectured that egg size has an effect on the growth and survival of young fry, however, little definitive work has been carried out (see Bagenal 1969 for review). In a study with Chinook salmon (*Oncorhynchus tschawytscha*), Fowler (1972) suggested that large eggs produce larger fry than do small eggs and that the former also grow faster. Age of female and size of eggs were confounded in these studies. During an earlier study we observed that fingerlings from age 3 female rainbow trout appeared to be growing faster than fingerlings from age 2 females. Since the two age classes had different egg sizes and represented fish from two distinct breeding groups, it was not possible to determine whether the observed difference in growth was due to size of eggs, age of the female or genetic

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differences between the groups. This report describes the results of an experiment designed to evaluate the influence of age of female and size of eggs on fingerling performance. Preliminary results have been reported elsewhere (Gall 1972).

METHODS

The experiment was performed at the Hot Creek State Hatchery, Mono County, California and utilized the Hot Creek (RTH) strain of rainbow trout. The RTH strain is maintained in two distinct genetic groups (i.e., separate breeding units) each one being reproduced in alternate years using 2-year-old spawners. Females from each unit are retained as 3-year-olds, but for production purposes only. In order to include each genetic group in the study both as age 2 and age 3 females, the experiment was repeated in two consecutive years, 1969 and 1970. We define the two genetic groups as ODD year and EVEN year classes according to the year in which the females were born. Thus the ODD females were age 2 in 1969 and age 3 in 1970, whereas the opposite was true for the EVEN females.

In each year 60 females from each age class were spawned in two groups of 30 females each, hereafter referred to as spawn groups. Females in spawn group 1 were spawned on September 10 and 12 and those of spawn group 2 on September 23 and 22 in 1969 and 1970, respectively. In 1969 females were sorted for ripeness every 7 days whereas they were sorted every 5 days in 1970. Females were spawned into individual containers and the eggs of each female fertilized with milt from a single age 2 male to produce full-sib progeny lots. Lots of eggs which failed to hatch were discarded and not included in the data.

After the eggs had been water hardened the volume of eggs per female was measured to the nearest 0.25 oz by allowing the eggs to settle in a volumetric cylinder. A 1-oz (volume) sample of eggs was counted to determine egg size. Number of eggs per female was calculated as the product of total volume and egg size. The eggs were hatched and the fingerlings reared in compartmentalized hatchery troughs. The dead eggs were removed and counted when each lot was visibly eyed. The number of eyed eggs was then determined by difference.

The data of hatching was recorded for each lot as the date on which the majority of the eggs had hatched; the time required for all eggs in a lot to hatch ranged from 36 to 48 hr. The size of the fingerlings was determined 25, 50, and 75 days after date of hatching by counting the number of fish in two 2-oz (weight) samples. The number of fingerlings present at 75 days was determined by multiplying the total weight (in ounces) of each lot by the estimated number of fish per ounce. The average size of fingerlings in each lot was taken as the inverse of fish per ounce. Fingerling loss was determined as the difference between the number of eyed eggs and the estimated number of fingerlings at 75 days after hatching and thus included hatching loss. Growth from 25 to 75 days was estimated for each lot by taking the difference between average fingerling size at the two ages.

Correlation and regression analyses were performed to evaluate the relationships among the different characters studied. A preliminary analysis of variance of the effect of year spawned and age of female

was also performed on all the data. It was discovered during these analyses that the data for fingerling loss and weight at 50 days contained a number of inconsistencies. Since it was assumed that errors were made in recording or estimating these results the two traits were not analyzed further.

Based on the results of the preliminary analyses, a least-squares model was developed to provide an analysis to separate, at least partially, the effects of age of female and egg size. These two parameters were highly correlated with each other so that inference about each had to be obtained indirectly. The model included number of eggs to remove its effect on growth of fingerlings. The data for percent eyed eggs, 25 and 75 day weight, and growth from 25 to 75 days were then analyzed for the effects of year spawned, spawn group, age of female, number of eggs, and interactions among year, group, and age effects. A second analysis was performed using a model which also included egg size as a regression term. The complete model was defined as follows:

$$Y_{ijkm} = u + Y_i + G_j + A_k + YG_{ij} + YA_{ik} + GA_{jk} + b_1 (X_{1ijkm} - \overline{X}_1) + b_2 (X_{2ijkm} - \overline{X}_2) + e_{ijkm}$$

where

Y_{ijkm} = observation on the m^{th} lot in the i^{th} year and j^{th} group and from k^{th} age female

u = overall mean

Y_i = effect of the i^{th} year spawned, $i = 1,2$

G_j = effect of the j^{th} spawn group, $j = 1,2$

A_k = effect of the k^{th} age of female, $k = 1,2$

YG_{ij} = effect of interaction between i^{th} year and j^{th} group

YA_{ik} = effect of interaction between i^{th} year and k^{th} age of female

GA_{jk} = effect of interaction between j^{th} group and k^{th} age of female

b_1, b_2 = regression of egg number and egg size, respectively, on Y_{ijkm}

X_{1ijkm}, X_{2ijkm} = observed egg number and egg size, respectively

$\overline{X}_1, \overline{X}_2$ = average egg number and egg size, respectively

RESULTS AND DISCUSSION

The distribution of egg size was similar in both years, however there was very little overlap in the size of eggs from 2- and 3-year-old females which generated a strong correlation (i.e. confounding) between age of the female and size of eggs spawned (Table 1). The average performance for all the traits measured is presented in Table 2. Age 3 females produced a greater volume of larger eggs than age 2 females and consequently a larger number of eggs. The difference in egg production for 3-year-olds in the 2 years was not expected. It was also observed that the variance in egg number for 3-year-olds was threefold larger in 1969 than in 1970 and was apparently due to some 1969 females producing a large number of eggs. For example, five females in 1969 produced more than 7,000 eggs, whereas in 1970 only four females produced in excess of 5,000 eggs. The percent eyed eggs obtained was slightly higher for 3-year-old females but this appears to have been offset by a higher fingerling loss.

TABLE 1. Distribution of Observations for Egg Size by Year Spawned and Age of Female

Class interval	Number of females					
	1969		1970		1969 all	1970 all
	Age 2	Age 3	Age 2	Age 3		
(No./oz)						
under 250	--	--	--	2	--	2
250–275	--	3	--	8	3	8
275–300	--	11	--	22	11	22
300–325	--	10	--	15	10	15
325–350	--	11	--	7	11	7
350–375	--	10	--	2	10	2
375–400	3	2	1	2	5	3
400–425	3	0	5	--	3	5
425–450	7	2	9	--	9	9
450–475	7	1	9	--	8	9
475–500	9	--	13	--	9	13
500–525	7	--	10	--	7	10
525–550	7	--	5	--	7	5
550–575	4	--	1	--	4	1
over 575	2	--	3	--	2	3
Total	49	50	56	58	99	114

TABLE 2. Average Performance by Year Spawned and Age of Female. The 1970 Age 3 Females Were the Same Fish as Those Spawned as Age 2 in 1969. The 1970 Age 2 Females Were Progeny of the 1969 Age 3 Females When They Were Spawned as Age 2 in 1968

Year	Age of female					
	2	3	2	3	2	3
	Egg size (No./oz)		Egg volume (oz)		Egg number (number)	
1969	485	329	6.5	16.2	3120	5302
1970	483	301	7.0	12.6	3341	3773
Average	484	315	6.8	14.4	3230	4537
	Eyed eggs (percent)		Fingerling loss (percent)		Growth (25–75 days) (oz $\times$ 10^{-2})	
1969	77.7	80.2	7.9	4.5	7.21	8.47
1970	84.4	91.4	10.8	18.8	6.70	8.27
Average	81.0	85.8	9.4	11.6	6.96	8.37
	25-day weight (oz $\times$ 10^{-2})		50-day weight (oz $\times$ 10^{-2})		75-day weight (oz $\times$ 10^{-2})	
1969	1.69	2.05	4.59	4.61	8.90	10.51
1970	1.11	1.42	3.58	4.49	7.81	9.70
Average	1.40	1.74	4.09	4.55	8.36	10.10

Progeny from age 3 females were heavier at 25, 50, and 75 days of age. The difference was not significant at 50 days probably due to discrepancies in the data noted earlier. In addition, the fingerlings from age 3 females grew 20% more rapidly than those from 2-year-olds. These observations are consistent with the conclusion drawn from selection data (Gall, unpublished) that size and growth differences found at young ages contain a large maternal component. Kincaid

(1972) has suggested that maternal effects are considerably reduced by 150 days of age.

Analysis of variance of mean performance by year and age of female demonstrated significant year, age, and year x age interaction effects on egg size, egg volume, and egg number (Table 3). Differences among years were expected due to chance environmental variation from year to year and past experience would also suggest that an age difference would be found. However, the existence of an interaction effect indicated that one could not predict how large the age difference might be for any particular year. Consideration of possible reasons for such an interaction immediately suggested that it may be due, at least in part, to differences between the two genetic groups used in the experiment. The average egg volume and egg number of the EVEN females was superior to the ODD females both as 2- and 3-year-olds making the age differences greater in 1969 than in 1970 (Table 2). Average egg size was similar for the two year classes when they were 2-year-olds, but the EVEN females had smaller eggs as 3-year-olds. The overall effect of the year-class differences was to cause a reversal of the ranking of performance of the two ages of females from one year to the next.

TABLE 3. Analysis of Variance of the Effects of Year Spawned and Age of Female on Mean Performance for Volume of Eggs, Size of Eggs and Number of Eggs

Source*	d.f.	Mean squares*		
		Egg size	Egg volume	Egg number
		(No./oz)	(oz)	(No. × 10³)
Year	1	28558.5‡	55.92‡	1707.0‡
Age	1	220.8†	2.56‡	427.1‡
Year × Age	1	160.0†	4.08‡	765.3‡
Error*	209	37.7	0.11	12.6

* Error mean square estimated from within year × age sum of squares and the harmonic mean (52.975) number of observations per subcell.
† Significant at P = 0.05.
‡ Significant at P = 0.01.

The relationship, within year and age of female, of egg size and number with percent eyed eggs and growth of fingerlings was evaluated by a correlation analysis (Table 4). These results were compared to correlation estimates obtained from all data ignoring years and ages and thus including the effects of the confounding of years and ages with the true relationships. Number of eggs was not correlated with percent eyed eggs except for 3-year-olds in 1969. Similarly, the correlation of egg size with percent eyed eggs was significant for only one of the 4 year-age groups; however, the correlation was significant when all data were considered reflecting the fact that age 3 females had a larger average egg size as well as a higher percent eyed eggs.

Number of eggs was significantly, negatively correlated with weight and growth in 6 of 12 combinations studied indicating that fingerlings from females that spawned large numbers of eggs tended to be smaller. The cause of this relationship is not likely to be due to egg size differ-

TABLE 4. **Simple Linear Correlations Coefficients for the Relationship of Size and Number of Eggs with Survival of Eggs and Growth Characteristics of Progeny from Age 2 and 3 Females in 1969 and 1970**

Age, year trait	Percent eyed eggs	Weights 25 day	Weights 75 day	Growth 25–75 days
Age 2, 1969				
Egg size	−.40*	−.51*	−.42*	−.31*
Egg number	.07	−.07	−.30*	−.34*
Age 2, 1970				
Egg size	−.01	−.69*	.02	.15
Egg number	.17	−.03	.02	.03
Age 3, 1969				
Egg size	−.04	−.49*	−.42*	−.27*
Egg number	−.38*	−.42*	−.20	−.06
Age 3, 1970				
Egg size	−.17	−.37*	−.14	−.08
Egg number	.08	−.36*	−.39*	−.33*
All data				
Egg size	−.26*	−.43*	−.52*	−.45*
Egg number	−.09	.21*	.21*	.17*

* Significant at P = .05.

ences because egg size is generally unrelated to number of eggs for any single age class (Gall 1973). The correlation obtained when all the data were analyzed again demonstrated the seriousness of the confounding effect of age of female. These latter correlations are positive because age 3 females, probably due to their greater size, produce larger numbers of eggs than 2-year-olds. The concomitant larger size of fingerlings from 3-year-old females may be due to their larger egg size but not to the larger number of eggs.

The negative correlations found for egg size and fingerling size suggest that there was a relatively strong positive relationship between egg size and growth, although the correlations differed between the 2 years. It is difficult to explain the lack of significance of the correlations for 75 day weight and growth from 25 to 75 days in 1970. It is possible that because the fish were small at 25 days, compensatory growth occurred to an extent which masked any differences related to egg size. When all the data were considered, consistent negative correlations were obtained; however these were again imposed by the confounding effects of age.

The least-squares models were used to achieve a gross separation of the effects of age of female and egg size on percent eyed eggs, 25 and 75 day weight, and growth from 25 to 75 days. The least-squares means and standard errors (Table 5) give the best estimates of the effects of each level of the factors in the models when all terms are considered simultaneously (Table 5). The interaction means are not included in the table for the sake of simplicity and with little loss of generality. The mean squares from an analysis of variance of the effect of all the terms in the models is presented to indicate the importance of each term (Table 6). The first model used (Column a, Tables 5 and

TABLE 5. **Least-squares Means and Standard Errors for the Analysis of the Effect of Year, Spawn Group and Age of Female on Percent Eyed Eggs, 25 and 75 Day Weight, and Growth of Fingerlings from 25 to 75 Days When Egg Number (a) and Egg Number and Egg Size (b) Were Included in the Model as Covariables**

Effect	Trait															
	Percent eyed eggs (degrees)				25-day weight (oz × 10^{-2})				75-day weight (oz × 10^{-2})				growth 25 to 75 days (oz × 10^{-2})			
	(a)		(b)		(a)		(b)		(a)		(b)		(a)		(b)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Overall	68.30	0.85	68.36	0.85	1.53	.018	1.54	.016	9.23	.094	9.24	.091	7.70	.087	7.70	.086
Year 69	66.15	1.31	66.43	1.30	1.88	.027	1.90	.024	9.82	.143	9.87	.140	7.94	.133	7.97	.132
70	70.44	1.21	70.28	1.21	1.18	.025	1.17	.022	8.64	.132	8.61	.129	7.46	.123	7.44	.122
Group A	66.56	1.23	67.11	1.25	1.27	.025	1.30	.023	9.22	.134	9.32	.134	7.95	.125	8.01	.126
B	70.03	1.21	69.60	1.22	1.80	.025	1.77	.022	9.24	.132	9.16	.130	7.45	.122	7.40	.123
Age 2	64.83	1.40	68.55	2.31	1.29	.029	1.54	.042	8.12	.153	8.81	.247	6.83	.142	7.27	.234
3	71.76	1.40	68.17	2.26	1.77	.029	1.53	.042	10.34	.154	9.67	.243	8.56	.143	8.14	.229
Regression on egg number	−.00197	.00107	−.00168	.00107	−.000084	.000022	−.000064	.000020	−.000363	.000117	−.000309	.000115	.000279	.000109	−.000245	.000108
Egg size			−.0412	.204			−.00250	.0038			−.00768	.00219			−.00488	.00207

TABLE 6. **Least-squares Analysis of Variance of the Effect of Year, Spawn Group and Age of Female on Percent Eyed Eggs, 25 and 75 Day Weight, and Growth from 25 to 75 Days When Egg Number (a) and Egg Number and Egg Size (b) Were Included in the Model as Covariables**

		Mean square							
		Percent eyed eggs (degrees)²		25-day weight (oz² × 10⁻⁴)		75-day weight (oz² × 10⁻⁴)		Growth 25–75 days (oz² × 10⁻⁴)	
Source	df	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Year (Y)	1	832.5†	664.3†	22.56‡	24.15‡	63.16‡	71.10‡	10.22†	12.37‡
Group (G)	1	621.6†	295.3	14.40‡	10.16‡	0.04	1.14	12.85‡	18.11‡
Age (A)	1	1511.6†	1.2	7.40‡	0.01	154.79‡	6.17	94.49‡	6.35†
Y × G	1	480.4	493.8	2.01‡	2.06‡	21.41‡	21.94‡	10.31†	10.54†
Y × A	1	4.8	0.3	0.08	0.08	0.98	1.69	0.66	1.02
G × A	1	0.2	17.3	0.30†	0.72‡	0.01	0.89	0.21	0.01
Regression on									
Egg number	1	524.4	374.0	0.95‡	0.54‡	17.83‡	12.66‡	10.56†	7.97†
Egg size	1	----	618.8†	----	2.86‡	----	21.53‡	----	8.70†
Error*	205	154.9	152.6	0.07	0.05	1.85	1.75	1.60	1.56

* Error degrees of freedom for analysis (b) = 204.
† Significant at P = .05.
‡ Significant at P = .01.

6) adjusted the data for differences in number of eggs spawned. Significant differences were found between years, spawn groups and ages of females for all traits except that the spawn groups did not differ in 75-day weight. Significant interactions occurred between years and spawn groups for 25 and 75 day weights and growth from 25 to 75 days. Weight at 25 days was also influenced by a spawn group by age of female interaction. In contrast to the results obtained for egg production, percent eyed eggs, 25 and 75 day weight, and growth were not effected by an interaction between year and age of female. Number of eggs was not an important source of variation in percent eyed eggs but was a major source of progeny group differences in weight and growth.

The second model (Column b, Table 5 and 6) was used to evaluate the importance of age of female when the data was adjusted for egg size as well as egg number. The regression on egg size accounted for a large proportion of the total variation in all four traits. This was obtained at the expense of losing age effects for percent eyed eggs and 25 and 75 day weight. A significant age effect remained for growth from 25 to 75 days even after removal of egg size differences. Although the results can only be considered as suggestive, they indicate that differences in progeny performance associated with differences in age of female can be accounted for by the variation in egg size. The data do establish, however, that large eggs produce larger, faster growing fingerlings at least through 75 days of age. These results agree with those of Fowler (1972), working with Chinook salmon, who observed a correlation of –.72 between egg size and first-feeding fish and –.63 between egg size and fingerling weight after a 4-week feeding period. Fowler also found that egg and fingerlng mortality increased as egg size increased. Our results show that percent eyed eggs would improve as egg size increased. It should be noted that inclusion of egg size in the least-squares model caused a slight reduction in the mean square for egg number. This was undoubtedly due to the existence of an overall correlation of –.37 between egg size and egg number.

If large eggs yield a higher hatchability and faster growing fingerlings, there are several important implications which could affect the efficiency of hatchery trout production. Selection of broodfish for larger eggs could result in stronger, larger fry which would be expected to feed more quickly and grow faster thus reducing early mortality. However, if 3-year-old females were used to produce the larger eggs the generation time required for selective breeding would be increased by 50% over that for a brood program based on 2-year-old fish. The increase in time required could be reduced by using age 2 males with age 3 females, but this would require that 2 year classes be continuously available for a selection program. Because of the obvious importance of resolving this question, further experiments are needed to evaluate the effects of egg size for 2-year-old fish.

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EXPLOITATION, SURVIVAL, GROWTH, AND COST OF STOCKED SILVER SALMON IN LAKE BERRYESSA, CALIFORNIA[1]

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Reward tagged and untagged silver salmon were stocked in Lake Berryessa, Napa County, California, in 1970 and 1971 to determine harvest, survival, growth rates, and cost. Total harvest was 0.380 and 0.390, with an estimated annual survival of 0.134 and 0.157 for 1970 and 1971, respectively. Silvers achieved a mean weight of 6 lb for the 1970 stocking and nearly 3 lb for 1971. The lower growth rate for 1971 is attributed to depleted stocks of adult threadfin shad during the winter. We postulate that this might have a beneficial effect on the year class strength of young-of-the-year largemouth bass. Cost/lb to the angler's creel of $.44 in 1970 and $.57 in 1971 was comparable to the most economical strain of rainbow trout stocked concurrently in Lake Berryessa. Silver salmon also demonstrated a lower early vulnerability to fishing than most domestic strains of rainbow trout stocked in California. Tags returned by anglers from silver salmon with a mean fork length of 6.8 inches underestimated the true harvest and did not accurately reflect the contribution of untagged fish of the same length to the fishery in 1970.

INTRODUCTION

California early recognized the potential of silver (coho) salmon (*Oncorhynchus kisutch*) in inland waters. In the early 1940's salmon fingerlings were introduced into Lake Almanor (Plumas County). An estimated 6% was caught (Calhoun and Emig MS). They achieved weights of 1½ to 3 lb and were well liked by anglers. However, a reliable source of eggs for inland waters was generally unavailable and further large scale stockings were terminated. Silver salmon have also shown the ability to obtain a large size in other waters. The most outstanding examples come from the Great Lakes. Annual plants of silvers have been made since 1966 in both Lake Superior and Lake Michigan. The average weight for the Lake Superior spawners was 2.9 lb (Laurie and Rahrer 1972) and 9.5 lb for the spawning runs in 1967, 1968, and 1969 in Lake Michigan (Wells and McLain 1972). Plants were also made in Lake Erie in 1969 with the spawning adults from the plants averaging nearly 6 lb (Hartman 1972).

Experiments have been in progress since 1968 to determine the feasibility of developing a "trophy trout" fishery in California reservoirs. This program involves planting trout at a size large enough (8 to 10 inches) to utilize abundant forage fish, chiefly threadfin shad (*Dorosoma petenense*), and to achieve a growth rate greater than a pound per year. Before 1970, fish used in these experiments included various strains of rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo*

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trutta). In 1970 and 1971, spurred by success in the Great Lakes and a reliable source of eggs from Oregon, silver salmon were included in the experiments.

This paper presents silver salmon exploitation and survival rates, growth, and cost per pound to the angler's creel during the first 2 years of introductions into Lake Berryessa.

This experiment was conducted at Lake Berryessa, an impoundment on Putah Creek, located in Napa County, California. The lake covers 20,000 acres at maximum storage capacity of 1.6 million acre-ft. It has a mean annual fluctuation of approximately 10 ft with a single fall overturn. A large volume of well-oxygenated water less than 60 F in the hypolimnion provides suitable habitat for salmonids during summer stratification. Threadfin shad were stocked in 1965 and subsequently developed an enormous stock in the limnetic zone. A typical California assemblage of introduced centrarchids and ictalurids exist in the littoral zone.

MATERIALS AND METHODS

American River Hatchery (Sacramento County) and Darrah Springs Hatchery (Shasta County) reared the salmon used in this experiment in 1970, while only the latter hatchery reared fish for the 1971 stockings. Fertilized eggs obtained from fish spawning in the Alsea River drainage, Oregon, provided the egg source for both hatcheries.

A total of 17,450 and 14,000 silver salmon was planted on April 14, 1970 and May 14, 1971, respectively. Of these, 395 were tagged in 1970 and 736 were tagged in 1971. Tagged fish had mean fork lengths of 6.8 and 8.1 inches with mean weights of 0.12 and 0.23 lb in 1970 and 1971, respectively (Table 1). Since unpublished data from previous experiments indicated that salmonids less than 9.0 inches suffered higher post-tagging mortality than larger fish, an additional 397 tagged fish were stocked on April 25, 1970 to test this hypothesis. These fish, of the same strain and age as the earlier plant, were reared at Darrah Springs Hatchery where growth was more rapid. This tagged group had a mean length of 8.9 inches and a mean weight of 0.28 lb.

TABLE 1. Length Frequencies, Mean Lengths, and Mean Weights of Tagged Silver Salmon Planted in Lake Berryessa in 1970 and 1971

Fork length class, inches	Number		
	April 14, 1970	April 25, 1970	May 14, 1971
6.0– 6.9	277	0	0
7.0– 7.9	114	56	322
8.0– 8.9	4	152	341
9.0– 9.9	0	161	49
10.0–10.9	0	26	9
11.0–11.9	0	2	11
12.0–12.9	0	0	4
13.0–13.9	0	0	0
Total	395	397	736
Mean fork length, inches	6.8	8.9	8.1
Mean weight, pounds	0.12	0.28	0.23

All fish were tagged with either Swedish trailer or internal anchor tags (Floy FD-67) which bore an offer of a $5 reward for their return. The Swedish trailer was made to the specifications of Nicola and Cordone (1969) and applied in a similar manner. Dell (1968) and Keller (1971) described the internal anchor tag and its method of application. Both tags proved equally efficient on silver salmon (Rawstron 1973*a*) and showed little effect on growth.

Publicity for the program has been widespread since similar studies involving trout have been in progress at Lake Berryessa since 1968. Publicity included talks to local sportsmen's groups and the placement of posters, which described the program, at conspicuous areas around the lake. We distributed franked envelopes to local businesses and resorts for the use of anglers who caught tagged fish.

Survival and exploitation rates were determined by Ricker's method (1958). Growth information was obtained primarily from weekend creel censuses each October.

RESULTS

Post-Tagging Mortality

Tag returns from the April 14, 1970 plant (mean weight 0.12 lb) totaled 11%, while the April 25, 1970 plant (mean weight 0.28 lb) totaled 38%. A creel census in October 1970 indicated that untagged silvers constituted 26.4% of the salmonid catch. This data supports the hypothesis that these smaller fish, amounting to only 12% of the total number of salmonids planted that year, suffered undue post-tagging mortality resulting in an underestimate of the harvest rate. Consequently, tagged fish of this plant are not considered in the determination of costs, mean annual exploitation rates, or survival rates for 1970, and only returns from the April 25 plant are considered.

Harvest and Survival

First year returns of 131 tags in 1970 and 248 tags in 1971 (Table 2) yielded similar first year exploitation rates of 0.330 and 0.337, respectively. Total exploitation rate in 1970 (0.380) was slightly lower, but not significantly different from that observed in 1971 (0.390). Estimated annual survival was 0.134 and 0.157 for 1970 and 1971, respectively.

Returns prior to October for each plant showed a low early vulnerability to anglers, with only 26.7% of the total catch returned during this period in 1970 and 27.8% in 1971 (Table 2). Pattern of monthly returns was similar for both years. Anglers caught the highest number in November (Tables 3 and 4).

Growth, Weight Returns, and Cost

No salmon from the 1970 plant were seen in the limited October 1971 census. The junior author observed four silvers in October and November and estimated their weights at 6 lb. In addition, the local warden, during routine patrol activities in August noted an increased incidence of large silvers in the catch. He estimated their weights at 4 to 6 lb with one individual near 8 lb (Graydon M. Harn, Department of Fish and Game, pers. comm.). Further, an angler won a local fishing derby for trout and salmon during October with a 7.0 lb silver salmon and a 12.5 lb silver was photographed, weighed, and measured

TABLE 2. Tag Returns and Exploitation and Survival Rates of Tagged Silver Salmon Planted in Lake Berryessa, 1970 and 1971

Year	Number tagged	Number returned			First-year exploitation	Total exploitation	Estimated annual survival	Percent total returns before 9-30
		Year 1	Year 2	Total				
1970	397	131	18	149	0.330	0.380	0.137	26.7
1971	736	248	39	287	0.337	0.390	0.157	27.8
Total	1,133	379	57	436				

at a resort November 2, 1971. These values closely parallel weights reported by anglers returning tags during the same time. Therefore, we assigned a conservative estimate of 6.0 lb as a mean weight for the month of October 1971. Based on these estimates silvers stocked in 1970 achieved a mean weight more than double that of silvers planted in 1971 (Figure 1).

Total planted weight of tagged fish for 1970 was 109.2 lb, while 169.3 lb were planted in 1971. Mean monthly weights were assigned based on the growth curves plotted in Figure 1. The number of returns each month was then multiplied by the mean monthly weight and the subsequent weights were summed to determine total estimated pounds harvested.

TABLE 3. Tag Returns through December 31, 1972 by Month and Year of Tagged Silver Salmon Planted in Lake Berryessa, April 25, 1970

Period	Number returned	
	Year 1 1970–1971	Year 2 1971–1972
April 25–30	0	3
May	11	3
June	5	3
July	6	4
August	1	1
September	12	1
October	15	1
November	29	2
December	19	0
January	11	0
February	6	0
March	6	0
April 1–24	10	0
Total	131	18

TABLE 4. Tag Returns through December 31, 1972 by Month and Year of Tagged Silver Salmon Planted in Lake Berryessa, May 14, 1971

Period	Number returned	
	Year 1 1971–1972	Year 2 1972–1973
May 14–30	7	5
June	9	7
July	11	8
August	22	4
September	20	3
October	15	5
November	40	4
December	27	3
January	24	--
February	24	--
March	31	--
April	9	--
May 1–13	9	--
Total	248	39

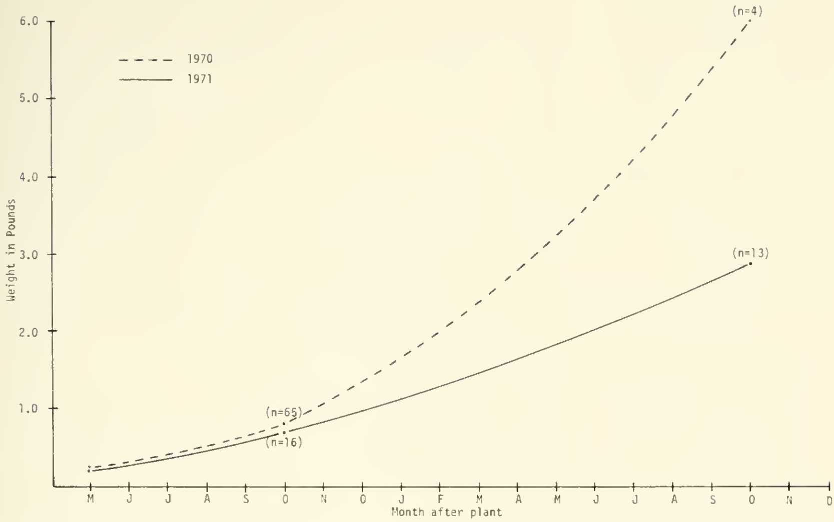

FIGURE 1. Growth rate of tagged silver salmon planted in Lake Berryessa, 1970 and 1971.

The 1970 plant yielded an estimated 251.0 lb and similarly, the 1971 plant yielded 337.4 lb (Table 5). The exact cost of hatchery production is not known, but was estimated at 1.5 times greater than rainbow trout (W. E. Schafer, Department of Fish and Game, pers. comm.). Cost of production for catchable trout (4/lb) was $.683 in 1970 (Bruley 1971) and $.759 in 1971 (Bruley 1972). Therefore, we used a cost of $1.02 in 1970 and $1.14 in 1971. Based on these values, calculated cost/lb to the angler's creel amounted to $.44 in 1970 and $.57 in 1971.

TABLE 5. Weight Returned and Cost/lb to the Angler's Creel of Tagged Silver Salmon Planted in Lake Berryessa, 1970 and 1971

Year	Weight planted (lb)	Weight returned (lb)	Percent Wt. returned / Wt. planted	Cost/lb hatchery	Cost/lb to angler's creel
1970	109.2	251.0	229.9	$1.02	$0.44
1971	169.3	337.4	199.3	$1.14	$0.57

DISCUSSION

Tagged silvers from the same group as those planted in Lake Berryessa were planted in Lake Almanor in 1970. The Almanor plant averaged 0.24 lb, returned 34.1% to the angler, and had a 146% return by weight (Hair 1972). Salmon introduced into Oroville Lake, California in May 1969 grew to 20 to 22 inches by August 1970 (Robert F. Elwell, Department of Fish and Game, pers. comm.). Subsequent introductions, however, have shown slower growth, with fish averaging 2 to 3 lb after 1½ years at large. The growth pattern exhibited for

these fish appears to be similar to that noted for Lake Berryessa. The early introductions apparently grow at a markedly superior rate and achieve larger size than later introductions. Their ultimate success appears to depend upon the abundance of adult threadfin shad available during winter. Anglers at Lake Berryessa reported during the winter of 1970–71 that silver salmon were gorged on shad to 3 to 4 inches long. Rainbow trout during this same period grew only slightly (Rawstron 1973*b*). Their stomachs generally contained plankton and debris. While not readily demonstrable, the effects of strong predation by piscivores during the summer, combined with heavy mortalities during cold winters, serves to deplete shad populations during winter, thus depriving the salmon of the necessary food supply for continuing rapid growth. The reduced growth of silvers in the 1971 plant at Lake Berryessa is attributed to severely reduced over-winter populations of shad. Anglers confirmed the reduced incidence of large shad in salmon stomachs. After June, however, when young-of-the-year shad were once again abundant, salmon growth accelerated. However, this winter predation presents other important management implications. Substantial benefits may accrue to the warmwater fishery. Von Geldern (1971) showed an inverse relationship between the numbers of adult threadfin shad and young-of-the-year largemouth bass (*Micropterus salmoides*). Heavy salmon predation on shad could reduce the impact of this inverse relationship and increase the size of the impending cohort of largemouth bass.

Using disk dangler or Swedish trailer tags on small silvers appears to result in dramatic underestimation of the contribution of untagged populations to the fishery. As mentioned earlier, tagged silver salmon averaging 0.23 lb returned at 300% of salmon tagged at 0.12 lb. These same irregularities have been noted for the 1970 group of tagged salmon at Lake Almanor. There, fish of identical sizes and from the same sources as those stocked in Lake Berryessa returned at 9.3% for the smaller fish and 34.1% for the larger (Hair 1972). The former group yielded an estimated 39.5% return of the weight planted while the latter showed 146%.

At Merle Collins Reservoir (Yuba County), a 1,000-acre impoundment managed similarly to Lake Berryessa, salmon from the same smaller group were tagged and planted on May 4, 1970. This group had a mean total harvest of only 8.8% for three different tag types combined and no survival to the second year (Rawstron 1973*a*). Untagged fish from this group seen in a creel survey, however, had a mean annual exploitation rate of 0.331 and an annual survival rate of 0.041. While not conclusive, silvers of the lighter group at Lake Berryessa comprised only 12% of the total number of salmonids stocked, but accounted for 26.4% of those observed during the October 1970 creel censuses, proving that these fish made a substantial contribution to that fishery. Again, at Lake Berryessa in 1972, 10,000 marked silvers planted in early March averaging 0.12 lb were compared to an equal number of fish from the same lot held until they achieved 0.20 lb in May. Creel census on several weekends in October showed that the initial group comprised 47.1% of the salmon observed with no significant differences in growth. We conclude that tagging of small silver salmon does not efficiently measure their real contribution to a sport

fishery. Additionally, the latter experiment also showed that silver salmon can be planted earlier, thus reducing the time that they are held in the hatchery.

The most economical strain of rainbow trout, Coleman Kamloops, cost \$.45/lb to the angler's creel in 1968, \$.86 in 1969, and \$.53 in 1970 (Rawstron 1972, 1973*b*). The costs reported here are comparable. Silver salmon, however, have the potential to attain larger size and they exhibit low vulnerability to angling immediately after stocking. Most of our domestic strains of rainbow trout consistently show reduced growth rates during winter and a higher initial vulnerability. If large populations of shad can be maintained during winter, silver salmon can realize this potential and provide another trophy fish for California's large impoundments at an economical cost.

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NOTES

SOUTHERN RANGE EXTENSION OF THE BAIRD CRAB (*CHIONOECETES BAIRDI* RATHBUN)

The incidence of Baird crab (*Chionoecetes bairdi*) south of Puget Sound, Washington is not recorded in the literature. The reported range (Rathbun, 1925) of this species was from the southeastern part of the Bering Sea and the Aleutian Islands eastward and southward to Kingcombe Inlet, British Columbia, in depths from shoal water to 259 fathoms (474 m). Slipp (1952) extended the southern range to Carr Inlet, Puget Sound. Since 1961, 20 specimens of Baird crab have been identified from catches made off the coast of Oregon by trawlers (Table 1) and represent southern extensions of the published range of this species.

A specimen taken off Winchester Bay, Oregon, on December 5, 1968, represents a range extension of 228 nautical miles (423 km) and establishes a new southern limit. This 85 mm (carapace width) female crab was captured in 145 fathoms (265 m) by the M/V *Ikaros II* at lat 43° 34′ N and long 124° 36′ W.

Nineteen other specimens were caught off the Oregon coast at depths of 125–190 fathoms (229–347 m). Eleven of these were captured off the mouth of the Columbia River from 1961 through 1963 by BCF personnel working on the University of Washington R/V *Commando* (W. T. Pereyra, pers. comm. 1970). Two additional Baird crabs were caught off Heceta Head by the M/V *Columbia*, one each in 1969 and 1970. Six crabs were captured from Yaquina Head to Cascade Head by the M/V *Destiny* from 1970 through 1972 and given to the Fish Commission of Oregon by the vessel's skipper, Captain Gordon White.

The Baird crab does not appear to be abundant off the Oregon coast. Personnel from Oregon State University School of Oceanography have conducted extensive biological sampling on the continental shelf and slope off Oregon and have no records of Baird crabs (J. McCauley and A. Carey, pers. comm. 1970, 1972).

Apparently, the Baird crab's bathymetric range off Oregon does not overlap with that of the Tanner crab (*Chionoecetes tanneri*). The Baird crab was found on the upper continental slope from 125–190 fathoms (229–347 m). Pereyra and Alton (1972) found Tanner crab only on the middle to lower part of the Oregon continental slope from 226–1,050 fathoms (413–1,920 m).

There has undoubtedly been confusion in the past in the identification between Baird crab and Tanner crab caught off Oregon. According to Garth (1958), the Tanner crab's carapace has expanded branchial regions which conceal the lateral margins. Between these branchial regions is a deep narrow depression. The Baird crab's carapace has depressed branchial regions which do not conceal the lateral margins, and there is no deep interspace between these branchial regions (Figure 1).

TABLE 1. Capture Information on Twenty Baird Crabs Collected Off Oregon

Capture vessel	Date	Locality*		Depth range, fathoms (m)	Number	Sex	Carapace width (mm) †
		Latitude	Longitude				
R/V Commando	July 5, 1961	46°02′ N	124°42′ W	125 (229)	5	--	--
R/V Commando	Sept. 12, 1961	45°59′ N	124°42′ W	148 (271)	3	--	--
R/V Commando	Dec. 9, 1961	46°04′ N	124°43′ W	150 (274)	1	--	--
R/V Commando	Aug. 27, 1962	46°02′ N	124°43′ W	125 (229)	1	--	--
R/V Commando	May 7, 1963	46°05′ N	124°39′ W	125 (229)	1	--	--
M/V Ikaros II	Dec. 5, 1968	43°34′ N	124°36′ W	145 (265)	1	F	85
M/V Columbia	Dec. 31, 1969	43°50′ N	124°53′ W	185–190 (338–347)	1	F	86
M/V Columbia	Jan. 1, 1970	43°50′ N	124°49′ W	184–188 (336–344)	1	M	--
M/V Destiny	Aug. 9, 1970	45°04′ N	124°23′ W	150 (274)	1	M	105
M/V Destiny	May 7, 1972	45°09′ N	124°22′ W	150 (274)	2	M	89
						F	77
M/V Destiny	May 9, 1972	44°40′ N	124°37′ W	135–140 (247–256)	2	F	75
						F	88
M/V Destiny	June 1, 1972	45°00′ N	124°26′ W	145–150 (265–274)	1	M	97

*Position given is at the center point of the fishing drag in which Baird crabs were caught.
†Carapace measured to nearest millimeter at greatest width, including spines, using vernier calipers.

While the Baird crab is not common off Oregon, it is an important commercial species in Alaska. Brown (1971) reported this species probably comprises over 95% of the Alaskan commercial catch sold as Tanner crab and is the only species of *Chionoecetes* fished commercially south or east of the Aleutian Islands. The Alaska Tanner crab catch was 14.4 million lb in 1970 (Anonymous 1971).

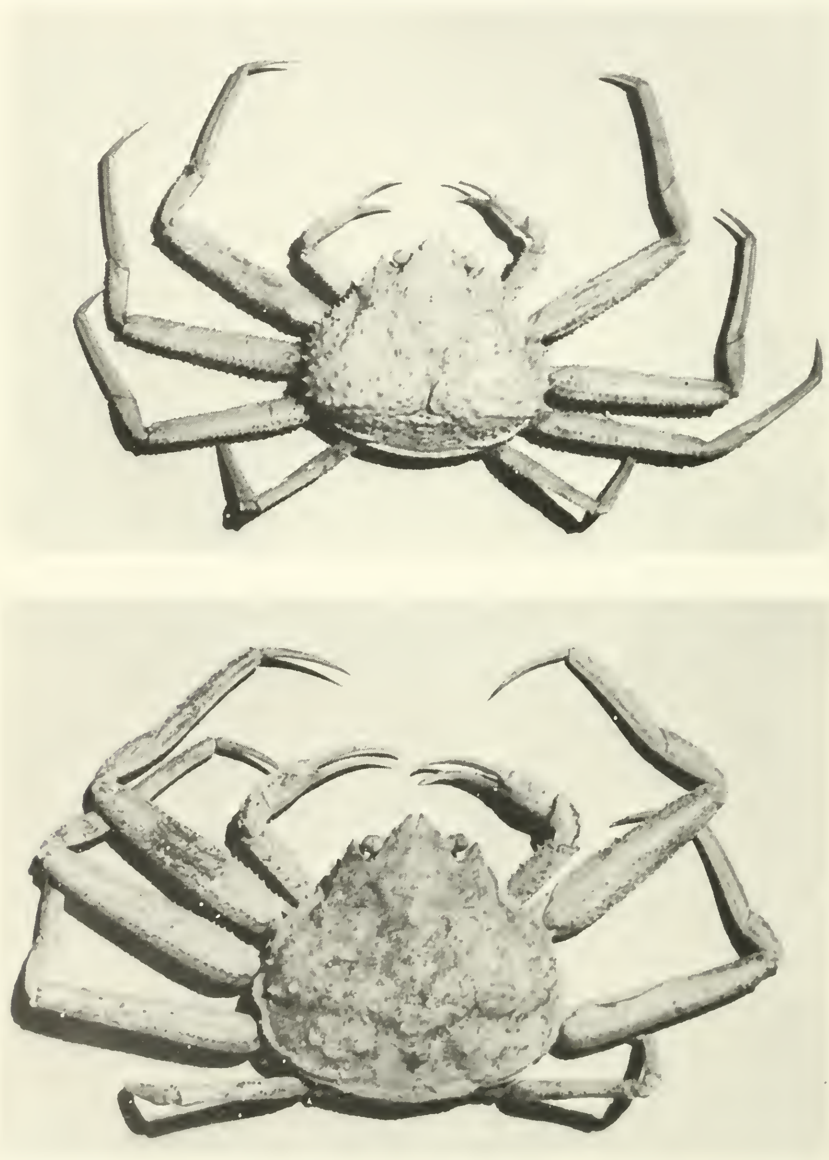

FIGURE 1. Dorsal view of a female Tanner crab (top) and a female Baird crab (bottom) showing morphological differences between the two species. (Photograph by G. G. Gibson)

ACKNOWLEDGMENTS

Several persons have assisted in compiling and verifying the foregoing information. The identity of the southernmost specimen collected was verified by Paul Rudy, Director of the University of Oregon Institute of Marine Biology. Walter Pereyra supplied the Bureau of Commercial Fisheries (now National Marine Fisheries Service) records of Baird crab off Oregon. James McCauley and Andrew Carey, Oregon State University School of Oceanography, reviewed records and collections for Baird crab specimens.

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PINNIPEDS OBSERVED IN RIVERS OF NORTHERN CALIFORNIA

Unconfirmed reports of harbor seals, *Phoca vitulina richardi*, seen as far inland as Sacramento stimulated a search for reliable sightings. Two recent observations reported to the Department of Fish and Game were forwarded to me for investigation.

On 14 January 1973, Michele Spieth and two companions, all of Sacramento, saw what they thought to be a ''log or dead dog'' in the American River approximately 4½ miles from its Sacramento River junction. The observers whistled at the ''dog'' whereupon it raised vertically out of the water and looked at them. Miss Spieth, who has had training in marine biology, recognized the animal as a harbor seal and followed it from the bank at a distance of about 8 ft for 3–4 min before it disappeared.

The next day, about 8 miles upstream, Edwin Bly, an experienced ocean diver from Carmichael, entered the river in his ''Royak'' boat to examine the shore of his property. He saw what he thought to be a ''log or dying dog'' drop from the bank into the water. The ''log'' popped up between his boat and the bank about 4 ft from the observer, who recognized it as a harbor seal. The seal rose out of the water ''chest high,'' looked at Mr. Bly and the length of the boat, then submerged vertically and disappeared.

Interviews with both observers indicate that each saw the same seal, and that it was not the tagged animal released in the south part of San Francisco Bay 27 June 1972 (Paulbitski and Maguire 1972). Both reporters had previous experience viewing pinnipeds, and both stated that upon close scrutiny, the seal appeared healthy. For the previous 2–3 days, Nimbus Dam, about 6 miles upstream from Mr. Bly, had been releasing 30,000 cfs into the river; this and unusually heavy winter rains created high water and a current of about 8 knots.

A very high river level may not be a requisite for harbor seal entry. *P. v. concolor* on Sable Island, Nova Scotia, travel overland 400–1600 yards to brackish Wallace Lakes (Renouf and James 1970). In re porting harbor seals, *P. v. richardi*, in the Skeena River of British Columbia, Fisher (1952) states, ''Seals will journey up any stream entering the Skeena that is deep enough for them to be assured of quick escape. The Lakelse River in places is barely deep enough, yet seals occur in Lakelse Lake.'' However, extensive human activity in the American River area where the reported observations were made may exclude seal entry during all but very high water levels.

In the San Francisco Bay system, harbor seals were documented as far inland as Grizzly Bay, about 40 miles northeast of the Golden Gate (Skinner 1962).

The range was extended to the northern junction of Steamboat Slough and the Sacramento River (Paulbitski and Maguire, op. cit.). Bonnot (1928) reported harbor seals in the south part of San Francisco

Bay, and I believe it probable that they range above Sacramento in the Sacramento River.

In comparing habitats frequented by fur seals, sea lions and harbor seals in British Columbia, Spalding (1964) stated that only the latter are known to occupy fresh water of rivers or lakes connected to their more preferred marine environment. Scheffer (1958) wrote that Steller and other sea lions are occasionally seen in rivers. He cited Weed (1936), who reported the capture of a Steller sea lion, *Eumetopias jubata*, in a pasture near Oregon City, Oregon, more than 90 miles from the ocean. Steller sea lions enter the Klamath River and range as far inland as the South Fork of the Trinity River (Humboldt County). Dr. Robert T. Orr (pers. comm.) possesses reports of sea lion sightings made by Robert Talmadge and others in 1962 and earlier years at Weitchpec junction of the Klamath and Trinity Rivers (about 35 miles from the Klamath's mouth) and at Hyampom on the South Fork of the Trinity (about 70 miles from the sea). These animals were identified as Steller sea lions by Mr. Talmadge, who is familiar with both this species and the California sea lion, *Zalophus californianus*.

On May 19, 1973, a 40 lb juvenile male California sea lion was netted by fishermen in the Mokelumne River near Thornton. Fish and Game Warden William E. Slawson directed the animal's transport to the Micke Grove Zoo near Lodi where it refused food and died May 25. Autopsy by Dr. Wilson Kelly of Stockton, showed the sea lion's stomach packed with small stones and fish vertebrae. Death was attributed to severe anemia and malnutrition.

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I offer my sincere appreciation to Inspector Kenneth Hooker and Warden William Slawson of the California Department of Fish and Game, Miss Michele Spieth, Mr. Edwin Bly, Mr. Robert Talmadge, Dr. Wilson Kelly and to members of the California Academy of Sciences: Dr. Robert T. Orr, Mrs. Jacqueline Shonewald and Mrs. Charlotte Dorsey.

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LEAD CONCENTRATIONS IN THE WOOLY SCULPIN, *CLINOCOTTUS ANALIS*, COLLECTED FROM TIDEPOOLS OF CALIFORNIA

The lead concentration in the muscle tissues of the wooly sculpin, *Clinocottus analis* (Girard, 1858), was examined for 12 fishes collected in the tidepools of the Pt. Fermin area of Los Angeles, 9 fishes taken from tidepools 11 miles north of San Simeon, and 9 fishes removed from tidepools near the isthmus of Santa Catalina Island. The method of analysis used is based on the precipitation of lead sulfate that is formed when muscle tissues are digested by concentrated sulfuric acid. The precipitated lead sulfate is dissolved in dilute nitric acid and the microgram quantities of lead is determined by atomic absorption (Munns and Holland 1970).

The average lead values of sculpins taken at Pt. Fermin was 4.9 ppm while the average lead level of sculpins collected at the isthmus of Santa Catalina Island was 2.7 ppm. The average lead concentrations for sculpins removed north of San Simeon was only 0.6 ppm.

Lead values of the tidepool fishes of San Simeon were of a magnitude similar to levels reported for salmon (1.3 ppm), tuna (0.9 ppm) and sardines (1.1 ppm) by J. C. Meranger and E. Somers (1968), and for anchovies (0.9 ppm) and sword fish (0.2 ppm) by H. A. Schroeder and J. J. Balassa (1961). The lead concentration of the Pt. Fermin wooly sculpins were almost five times greater than the previously mentioned values while the Santa Catalina sculpins contained more than twice as much lead.

The geographical variations in the lead levels in these tidepool fishes undoubtedly reflects the contamination of the intertidal zone by atmospheric lead pollution. P. C. Blocker (1972) indicated that the inner city of the Los Angeles Metropolitan Area contained almost 35 times more atmospheric lead than remote mountainous areas of California and almost 9 times more atmospheric lead than "composite rural areas."

The San Simeon region easily qualifies as a rural area in that it is removed from any major metropolitan area and has no major highways passing through it. Perhaps it is more than a coincidence that the lead levels in the tidepool fishes of this area is about 8 times less than the Los Angeles area. Santa Catalina Island is separated from the mainland by the Santa Catalina Channel with the isthmus being about 19 miles southwest of Pt. Fermin. It seems reasonable to conclude that the island lies close enough to Los Angeles to receive some of its atmospheric pollution. This conclusion is supported by the fact that the lead concentrations of the tidepool fishes of the isthmus area is about half as great as at Los Angeles but more than four times greater than the San Simeon area.

This study represents a preliminary examination of the lead concentration of one species of intertidal fish and suggests that levels of lead

in the intertidal environment may vary from metropolitan areas to rural areas, however, it does not indicate how the lead enters the food chain or the levels existing in the intertidal invertebrates and other intertidal fishes. Perhaps this common intertidal fish can be used as an indicator organism to reflect the accumulation of lead in the intertidal environment which is derived from air pollution.

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FIRST YEAR HARVEST RATES OF LARGEMOUTH BASS AT FOLSOM LAKE AND LAKE BERRYESSA, CALIFORNIA

Recent studies have shown that largemouth bass (*Micropterus salmoides*) may be overexploited in California's large reservoirs (Rawstron and Hashagen 1972; von Geldern 1972). This note presents further information on angler harvest rates of largemouth bass from two major reservoirs, Folsom Lake and Lake Berryessa. The former lake, a 10,000-acre fluctuating reservoir, has been described by Tharratt (1966). Its limnology and certain characteristics of the fishery have also been described (Rawstron 1964, 1967; Chamberlain 1972; von Geldern 1964). Lake Berryessa covers 20,000 acres and is similar to Folsom Lake in most respects except that annual fluctuations are substantially less.

At Folsom Lake, 178 adult largemouth bass ranging from 10.0 to 20.0 inches FL were captured by night electrofishing during March and April 1972. They were tagged with disk dangler tags (modified Atkins) (Chadwick 1963) which offered a \$5 reward for their return. Anglers returned 84 tags during the first year yielding an exploitation rate of 0.47. This value is similar to the first year rate of 0.48 reported for largemouth bass at Folsom Lake in 1962 (Rawstron 1967). However, in the intervening years, angling effort has decreased dramatically (junior author, unpublished data), and catch/hr for proficient bass anglers has declined from 0.20 in 1962 (von Geldern 1972) to 0.12 in 1973 (junior author, unpublished data). Moreover, the relative fraction of smallmouth bass (*Micropterus dolomieui*) in the total catch of black bass has increased from about 59% (von Geldern 1972) to 73% in the same period (junior author, unpublished data). The largemouth bass population appears to have declined during the last 10 years, but anglers continue to harvest a similar proportion of the available stock. This, coupled with differential exploitation rates of bluegill and other competing species (von Geldern 1972) signals a continued downward trend in largemouth bass populations at Folsom Lake.

At Lake Berryessa, anglers participating in a bass tournament provided 67 bass for tagging. Disk dangler tags offering a \$5 reward were placed on all these fish. All fish tagged were greater than 12.0 inches TL. Most were returned to the area where they had been caught. Anglers have returned 39 tags during the first year for an exploitation rate of 0.58. This value ranks among the highest reported for large lakes (Rawstron and Hashagen 1972). Limited data from past creel censuses and the views of veteran anglers indicate an increasing proportion of smallmouth bass in the catch and a declining catch/hr here also.

Exploitation rates, coupled with catch composition and catch/hr data presented here, are consistent with those reported in largemouth bass population trends for Merle Collins Reservoir (Rawstron and Hashagen 1972) and Folsom Lake (von Geldern 1972). If largemouth

bass populations continue to be harvested at high rates, especially when compared to competing species, angling opportunities for this species will be severely reduced in California's large reservoirs. Therefore, the California Department of Fish and Game's objective to provide quality angling opportunities for largemouth bass in California's large reservoirs should remain of the highest priority.

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STATUS OF MARTEN IN NORTHERN CALIFORNIA, OREGON AND WASHINGTON

Grinnell, Dixon and Linsdale (1937), considered two subspecies of marten (*Martes caurina*) occurring in California. *M.c. sierrae* ranged from above the 6,000 ft level from Jordan Hot Springs, Tulare County, north to Mount Shasta, Siskiyou County, west and northwest through the Trinity, Scott and Salmon mountains in Trinity and Siskiyou counties. It was known to have ranged from 4,000 ft elevation near Weed, Siskiyou County to 10,600 ft in the Mount Whitney area.

Martes c. humboldtensis ranged from the Oregon Line south through Del Norte, Humboldt and Mendocino counties mainly in the redwood

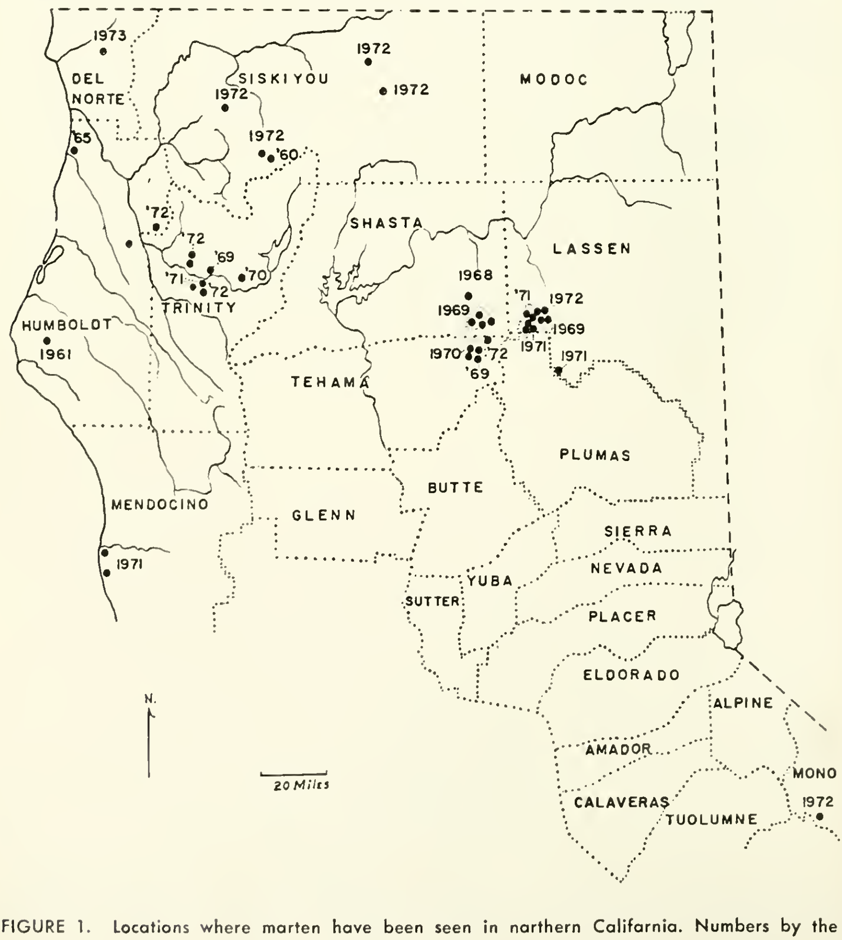

FIGURE 1. Locations where marten have been seen in northern California. Numbers by the dots indicate the year the animal was seen.

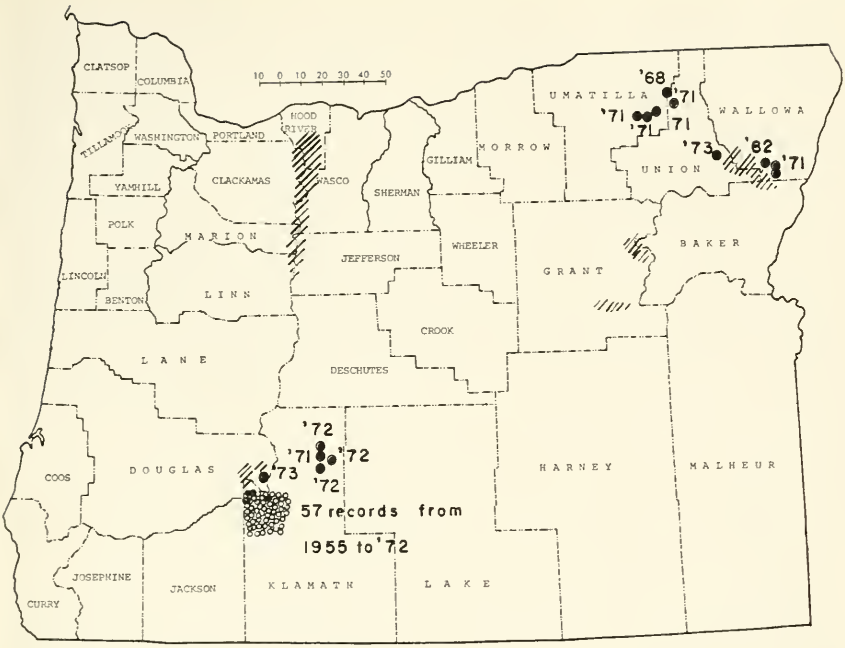

FIGURE 2. Locations where marten hove been seen in Oregon. Slanted lines indicate areas used by marten where no recent sightings have been specifically indicated.

region (at least formerly), to as far as Fort Ross, Sonoma County. This subspecies was found from near sea level to about 3,000 ft elevation.

Over several years, I have recorded records of marten seen by various observers in northern California (Figure 1). There are scattered records for *M. c. humboldtensis* along the California coast from Mendocino County to mid-Humboldt County. Several records from the Trinity River area, a few from Siskiyou County, clusters of records from around Lassen National Park are all assumed to represent the race *sierrae.*

I have no marten records for coastal Oregon, southern areas along the Oregon-California state line or from northeastern California.

This species must be far more abundant than my records indicate. Apparently, marten are increasing in the high country of Siskiyou and Trinity counties based on sign seen by qualified personnel who have been in the high country during summer months.

U.S. Forest Service personnel report having 38 sightings of marten during the last 2 years in the Trinity River drainage of the Trinity-Shasta National Forest which indicates an increase in the marten populations.

Dalquest (1948) and Miller and Kellogg (1955) indicated that two subspecies of marten were in Washington and Oregon. *Martes caurina caurina* is the form on the western slopes of coastal mountains from western Oregon and Washington north along British Columbia coastal mountains to the Alaska Panhandle extending up the Fraser and Thompson river valleys as far as Lillopet, and Bella Coola area to

Caribou and Rainbow mountains. Dalquest (1948) refers to the Cascade marten as *Martes caurina caurina* in absence of sufficient materials. I assume that the marten of the Oregon Cascades is also of the same race.

Martes caurina origenes was the subspecies found in the Rocky Mountains extending from New Mexico, Colorado, Utah, Wyoming and Idaho into the mountains of northeastern Washington and into the Blue Mountain of southeast Washington and northeast Oregon.

Looking at Washington (Figure 3), there appears to be many marten of the race *caurina* in the north and central Cascades with recent records along the north edge of the Olympic Mountains.

Recent Oregon records (Figure 2) for this race are concentrated in Klamath County, but marten must occur all along the backbone of the Cascades. No recent sight records were submitted from the Oregon coastal mountains although Forest Service personnel indicated that marten sign occurred in various places in the Siuslaw National Forest. In Oregon, *origenes* appears to be increasing in the counties of Umatilla, Union, Wallowa, Grant and Baker. This area encompasses the Blue Mountains of northeast Oregon including the high Wallowa Mountains.

In Washington, *origenes* is known to occur presently along the Washington-Idaho line. I have no recent records for the Blue Mountain area of southeast Washington, although marten must still occur there.

Like the wolverine (Yocom 1973*a*; Yocom 1973*b*) and the fisher (Yocom and McCollum 1973), the marten appears to be increasing at least in some portions of its former range. I have no good explanation for these population increases. In the case of the marten, three subspecies are involved covering coastal mountains, Olympics, Cascades and portions of the Rocky Mountains.

Records were submitted to me by personnel from the U.S. National Forest Service, U.S. National Park Service, and friends.

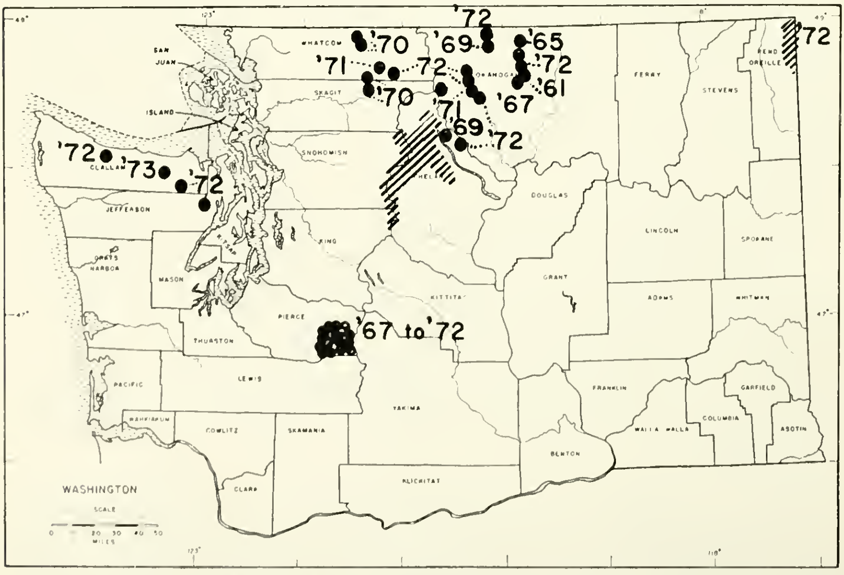

FIGURE 3. Locations where marten have been seen in Washington. Slanted lines indicate areas used by marten where no recent sightings have been specifically indicated.

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Charles F. Yocom, School of Natural Resources, California State University, Humboldt, Arcata, California 95521. *Accepted for Publication September 1973.*

BOOK REVIEWS

Environmental Toxicology of Pesticides

Edited by Fumio Matsumura, G. Malory Boush and Tomomasa Misato; Academic Press, London-New York, Illustrated; 1972, Xiv + 637 p. $19.50.

This compilation of papers presented at a United States-Japan seminar in Oiso, Japan during October of 1971 covers a wide range of problems involved with pesticides and the environment. Contributors of papers came from the United States, Japan, England, and Canada making this a truly international meeting.

The papers reflect the various environmental, political and economic pressures in these countries; thus, pressures in Japan for enough food to be grown on their limited acreage to feed their millions, in general, have taken precedence over ecological concerns until only recently. Now there is increasing concern for the effects of pesticides on the environment and many of the papers presented reflect efforts to find means of pest control which offer the least hazard to animals and fish as well as to humans.

The topics of food, water, air and soil contamination by pesticides are covered in detail. The main emphasis is placed on the pesticide compounds which are very stable, long lasting and capable of food chain contamination, namely BHC and DDT. A section on pollution by compounds of mercury is very informative. It is extremely pertinent to the problem of environmental contamination due to the occurrence of Minimata Disease in areas of Japan where fish have been allowed to become contaminated with residues of methylmercury compounds.

The various topics covered are all interesting but of particular importance to persons interested specifically in effects of pesticides on wildlife are Part III, Chlorinated Hydrocarbon Insecticides in the Environment and Part VII, Toxic Effect of Pesticide Residues on Wildlife. In Part III the factors relating to bioconcentration of pesticide residues and the mechanisms of long-distance transport of pesticides are discussed. In Part VII the dynamics of bioconcentration and ecosystemic transferal of pesticide residues are discussed. A specific example is the DDD contamination and subsequent decline of the Western Grebe (*Aechmophorus occidentalis*) at Clear Lake, California.

The sections regarding microbial degradation and photodecomposition of pesticides, the design of new pesticides (which includes a paper on methods of biological control) are interesting on an academic level, as is the part on fungicides, herbicides, organophosphates, and carbamates. The papers presented in these sections do a fine job of rounding out the coverage of a topic as wide and diverse as the Environmental Toxicology of Pesticides.

As in every book dealing with an emotional subject such as this, it is very difficult for the several authors to maintain complete objectivity. But with 29 papers dealing with various phases of this topic, it is possible for a person to come away with a comfortable feeling, for it seems there is an equal number of authors who present views with which you agree as those with which you do not agree. This book would be a fine addition to the library of any person who is concerned with the well-being of our wildlife and wants to broaden his knowledge of the how's and why's of pesticide contamination in our environment.—*William T. Castle*

Fish Farming International, No. 1

Peter Hjul (Editor); Fishing News (Books) Ltd., 23 Rosemount Avenue, West Byfleet, Surrey, England and 110 Fleet Street, London EC4A 2JL. 152 pages, illustrated. 1973 £3.00.

Fishing News (Books) Ltd., publisher of a number of informative references on aquaculture in recent years, launches a new endeavor with *Fish Farming International*. This first issue, intended as a review, includes 32 articles that provide one of the most up-to-date accounts of aquaculture programs, progress and developments on a world-wide basis.

Aquaculture practices spanning fresh, brackish and sea water; and algae, invertebrate and finned-fish culture are inclusive. Articles are written in sufficient depth so as to lend an insight to the economics and problem areas in this developing field.

Following an informative editorial introduction, Dr. H. A. Cole, Controller of Fisheries Research and Development for the United Kingdom, presents an elucidating article, *The Cultivation of Marine Fish and Shellfish.* Dr. Cole cursorily examines the selection of species for aquaculture, various aspects of their cultivation, and establishes the theme for ensuing articles.

Fish Farming International is designed for periodic publication. If subsequent issues provide up-to-date information comparable to this first edition, then it will prove a valuable reference to the fishery scientist-aquaculturist.—*Earl E. Ebert.*

Fly-Tying Materials

By Eric Leiser; Crown Publishers, Inc., N.Y., 1973; xi + 191 p. illustrated. $7.50.

The full title of this book is actually "Fly-Tying Materials—Their Procurement, Use, and Protection", and with all the books available today on fly fishing and fly tying, I know of no other book which presents the information provided in this book.

Leiser gives a clear, illustrated discussion of the common fly-tying materials which are available to both the commercial and non-commercial tyer—furs, feathers, tools, hooks. The main portion of the book provides information, also illustrated, on the procurement, preparation, and preservation of fur and feathers. There are detailed chapters on bleaching and dyeing and unusual uses for natural and synthetic materials. The book includes with brief discussions of prohibited species, federal regulations for importation of materials, and addresses of quality fly shops. The book has a lot of information and, I feel, is well worth the $7.50 asked.—*K. A. Hashagen, Jr.*

Amphibians and Reptiles of California

By Robert C. Stebbins; University of California Press, Berkeley, Los Angeles, and London, 1972; 152 p. illustrated, 8 color plates. $2.75.

This book describes 123 species of native California amphibians and reptiles (including two well established introduced forms) and six introduced species of doubtful status. Dr. Stebbins has included a section on general natural history and conservation, including a list of rare and endangered species and a checklist of California amphibians and reptiles. Information on the various species includes a description of their size and color, habitat, range, habits, and food; identification keys and distribution maps are not included. The illustrations and color plates are excellent.

For the beginner or the expert, *Amphibians and Reptiles of California* offers a wealth of information at a reasonable price.—*John M. Brode*

Rattlesnakes (two volumes, boxed)

By Lawrence M. Klauber, University of California Press, Berkeley and Los Angeles, 1973; 1533 p. illustrated, 2 color plates. $50.00.

The complete title of this work—*Rattlesnakes—Their Habits, Life Histories, and Influence on Mankind*—only hints at the astronomical amount of information contained in it. Mr. Klauber has combined maticulous accounts of his own experiences with an exhaustive review of the literature to produce two volumes of information which is *the* authority on rattlesnakes.

Volume one covers the identification and classification of rattlesnakes and includes information on morphology, physiology, behavior, and ecology. Volume two deals with rattlesnakes in relation to man and includes snake bite and its treatment, description of the poison apparatus, control and utilization of rattlesnakes, enemies of rattlesnakes, and myths, folklore, and tall stories concerning rattlesnakes. Although this work is expensive, it is well worth the price, considering the amount of information it contains and the time and dedication put into it by the author. If you want to know anything about them, *Rattlesnakes* has the answer.—*John M. Brode*

Conservation and Productivity of Natural Waters

By R. W. Edwards and D. J. Garrod, Editors: Symposia of the Zoological Society of London Number 29; Academic Press, New York. 1972; XV + 318 p. illustrated. $17.00.

This book reports the contributions of two dozen aquatic scientists to a 1970 symposium on biological productivity organized jointly by the British Ecological Society and the Zoological Society of London. The Societies invited leading British scientists who are confronting challenging problems in their efforts to conserve and enhance the productivity of Britain's marine and freshwater fishery resources. The

fifteen papers of the resulting symposium document the application of concepts and methodologies derived from current aquatic productivity research to the problems of optimizing desirable fishery productivity.

The first seven papers concern freshwater investigation: plant growth, nutrient budgets, and productivity of river ecosystems; application of limnological research in water supply system design and management; the impact of various levels of pollution on fisheries; N. C. Morgan, Nature Conservancy, authors an imaginative paper on conserving freshwater ecosystems with emphasis on selection and preservation of nature reserves. The theory of fish production in freshwater is discussed by E. D. Le Cren. His paper includes an informative illustration of the use of survival-growth ("Allen") curves in estimating fish production.

Marine topics are discussed in eight papers: conservation of deep-sea fisheries; laboratory and field investigations into zooplankton production, and marine productivity; food intake, growth, and fish production; application of radioecology in productivity studies; D. H. Cushing's paper on the production cycle and numbers of marine fish is illustrative of the application of predictive population dynamics theory, here predicting plaice recruitment in the southern North Sea with input of density-dependent/independent and competitive parameters. An interesting paper by J. J. Zijlstra summarizes the research program investigating the value of the Waddensea in the Netherlands as nursery area for North Sea commercial fisheries, a tidal area that may possibly be diked and closed off from the Sea.

Ease of reading varies with the writing styles of the contributors. There are author, systematic, and subject indices. The table of contents offers an individual subject outline for each of the 15 papers and concluding remarks. Bibliographies follow each paper.

The principal value of this text is the documentation of efforts by leading research scientists to solve some of Britain's most complex fishery conservation and productivity problems. The application of the latest concepts and methodologies in sampling and evaluating parameters of fishery productivity will be of interest to all aquatic biologists.—*Keith R. Anderson*

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